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QUADRANT II RFI FINAL REPORT

for

Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

VOLUME 1

Text/Figures/Tables

Released for Public Review

2289

Department of Energy
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P.O. Box 700
Piketon, Ohio 45661-0700
Phone: 614-897-5010

October 16, 1996
EF-21-7977

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Ms. Linda Welch, Chief
Division of Solid and Hazardous Waste
Ohio Environmental Protection Agency
P. O. Box 1049
Columbus, Ohio 43266-0149

Dear Mesdames/Sir:

SUBMITTAL OF QUADRANT II RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) FACILITY INVESTIGATION (RFI) FINAL REPORT

Enclosed is a copy of the Quadrant II RFI Final Report (Revision D3). The deliverable consists of two parts:

1. Volume One (in binder)
2. Revised pages for Volume Two through Five (in expandable folder)

A sheet of instructions detailing the procedure for replacing and inserting pages of the Quadrant II RFI report is included in the inside cover of Volume One. Also included inside the folder is the Roadmap for Responses to OEPA and USEPA comments, which is a guide to the exact locations in the text where each comment is addressed.

If you have any questions or comments regarding this submittal, please contact Lynn Kantner at (614) 897-5522.

Sincerely,

Eugene W. Gillespie
Site Manager
Portsmouth Site Office

EF-21:Kantner

Enclosures

cc: Administrative Records, MS-7614
T. David Taylor, LMES-PORTS
Celeste Lipp, Ohio Dept of Health
John Grabs, PRC Management

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June 5, 1997
EF-21-8473

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Ms. Celeste Lipp
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Dear Mesdames/Sir:

SUBMITTAL OF REVISED PAGES AND RESPONSE TO THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA) COMPREHENSIVE REVIEW OF THE QUADRANT II RCRA FACILITY INVESTIGATION (RFI) REPORT, PORTSMOUTH GASEOUS DIFFUSION PLANT, PIKETON, OHIO OH 7 890 008 983

Enclosed please find the subject page changes addressing the USEPA comments of February 4, 1997, on the Quadrant II RFI. On March 5, 1997, a telephone conference with USEPA Region V, Ohio EPA and DOE was held regarding results of the USEPA comprehensive review of the Quadrant II RFI. Consistent with agency agreements during that call, the enclosed includes a narrative response for major comments/concerns with the understanding that the Quadrant II RFI report should be finalized and any new information pertinent to site characterization will be documented in subsequent transmittals appropriate to the status of the remediation process at that time.

If you have any questions, please contact Ms. Lynn Kantner at (614) 897-5522.

Sincerely,

Eugene W. Gillespie
Eugene W. Gillespie
Site Manager
Portsmouth Site Office

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cc: T. David Taylor, LMES-PORTS

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October 22, 1997
EF-21-8805

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Dear Mesdames:

ADDITIONAL PAGE TO THE QUADRANT I, II, III AND IV RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) FACILITY INVESTIGATION (RFI) FINAL REPORTS

Enclosed is a copy of an additional page to the Quadrant I, II, III, and IV RFI Final Reports. As previously agreed, this page is to be inserted into its respective report to incorporate the Polycyclic Aromatic Hydrocarbon (PAH) position paper into the RFI Final Report. Please insert enclosed pages as the first page within the Executive Summary section of each report.

If you have any questions, please contact Kristi Wiehle of my staff at (614) 897-5020.

Sincerely,

for John Sheppard
Eugene W. Gillespie
Site Manager
Portsmouth Site Office

EF-21:Wiehle

cc: Administrative Records, MS-7614
T. David Taylor, LMES-PORTS
Gene Jablonowski, USEPA

DOE/OR/11-1232/V1&D3
POEF-ER-4583/V1&D3
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QUADRANT II RFI FINAL REPORT

for
Portsmouth Gaseous Diffusion Plant
Piketon, Ohio

VOLUME 1

Text/Figures/Tables

September 30, 1996

By

Geraghty & Miller, Inc.
Environmental Services
Under LMES Contract 30B-00001B

Prepared For
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
Under Budget and Reporting Code EW2010301

LOCKHEED MARTIN ENERGY SYSTEMS, INC.
Environmental Restoration and Waste Management
P.O. Box 628 Piketon, Ohio 45661

Under Contract DE-AC05-76OR00001
to the
U.S. Department of Energy

First Draft Issued Unnumbered
Actual Date February 19, 1992

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APPENDIX C - QA/QC SUMMARY REPORT
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LIST OF ABBREVIATIONS

ACGIH	American Council of Governmental and Industrial Hygienists
AET	Adverse Effects Threshold
ATSDR	Agency for Toxic Substances and Disease Registry
ARARs	Applicable or Relevant and Appropriate Requirements
AWQB	Ambient Water Quality Benchmarks
BARA	Barren Area
Bedford	Bedford Shale
BERA	Baseline Ecological Risk Assessment
Berea	Berea Sandstone
BOD	Biological Oxygen Demand
BRA	Baseline Risk Assessment
BRC	Big Run Creek
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CDC	Centers for Disease Control
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Ci/hr	Curies per hour
cm^2/sec	Square centimeters per second
cm^3/g	Cubic centimeters per gram
CMS	Corrective Measures Study
CO_2	Carbon Dioxide
COC	Chemicals of Concern
CPCB	Chemical and Petroleum Containment Basins
CPSC	Consumer Product Safety Commission

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LIST OF ABBREVIATIONS (continued)

CPVC	Chlorinated polyvinyl chloride
Cuyahoga	Cuyahoga Shale
DOCC	Description of Current Conditions
DQOs	Data quality objectives
ECAO	Environmental Criteria and Assessment Office
ED	Exposure duration
EDD	East Drainage Ditch
EDE	Effective dose equivalent
Energy Systems	Lockheed Martin Energy Systems, Inc.
ER-L	Effects range low (10% of exposed aquatic organisms expected to show toxic effects)
ER-M	Effects Range-Median
ESD	Environmental Services Division
eV	Electron volts
ft/d	Feet per day
ft^2/d	Square feet per day
ft^3/d	Cubic feet per day
f_{oc}	Fraction of organic carbon
Gallia	Gallia Sand and Gravel
gal/month	Gallons per month
g/cm^3	Grams per cubic centimeter
GC	Gas chromatograph
GCEP	Gaseous Centrifuge Enrichment Process
G.I.	Gastrointestinal
gpd	Gallons per day
gpm	Gallons per minute

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LIST OF ABBREVIATIONS (continued)

GSD	Geometric Standard Deviation
GTGS	Geotechnical Graphic System
GWQA	Groundwater Quality Assessment
HAZWRAP	Hazardous Waste Remedial Action Program
HEAST	Health Effects Assessment Summary Tables
HEPA	High Efficiency Particulate Air
HF	Hydrogen Fluoride
HI	Hazard index for noncarcinogenic effects
HQ	Hazard quotient
HSDB	Hazardous Substances Data Bank
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
IDLH	Immediate Danger to Life and Health
in/yr	Inches per year
IRIS	Integrated Risk Information System
IRM	Interim Remedial Measure
kg	Kilogram
kg/yr	Kilograms per year
K_{ow}	Octanol-water partition coefficient
lbs	Pounds
LBC	Little Beaver Creek
LC_{50}	Lethal concentration in 50% of animals exposed
LOAEL	Lowest-observed-adverse-effect level
m^3/day	Cubic meters per day
mg/l	Milligrams per liter

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mg/kg	Milligrams per kilogram
$mg/m^2/day$	Milligrams of chemical per square meter body surface area per day
mg/m^3	Milligrams per cubic meter
mg U/kg	Milligrams of uranium per kilogram
mg U/liter	Milligrams of uranium per liter
mgd	Million gallons per day
Minford	Minford Clay and Silt
MOC	Method of Characteristics
MMOC	Modified Method of Characteristics
msl	Mean Sea Level
N	Normality
NA	Not Analyzed
ND	Not Detected
NDD	North Drainage Ditch
NEDD	Northeast Drainage Ditch
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Association
NOAEL	No-observed-adverse-effect level
NPDES	National Pollution Discharge Elimination System
NRC	National Research Council
NTP	National Toxicological Program
NCP	National Oil and Hazardous Substances Pollution Contingency
NCRPM	National Council on Radiation Protection and Measurements
NYSDEC	New York State Department of Environmental Conservation
ODNR	Ohio Department of Natural Resources

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LIST OF ABBREVIATIONS (continued)

OEPA	Ohio Environmental Protection Agency
OFR	Old Northwest Firing Range
ORNL	Oak Ridge National Laboratory
OSTP	Office of Science and Technology Policy
PAHs	Polynuclear aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCDFs	Polychlorinated dibenzofurans
PCE	Perchloroethylene
PCG	Preconditioned conjugate gradient
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
PERA	Preliminary Ecological Risk Assessment
PHYTOTOX	U.S. EPA plant toxicity database
PORTS	Portsmouth Gaseous Diffusion Plant
ppb	Parts per billion
ppm	Parts per million
PQLs	Practical quantitation limits
PRCL	Process Waste Lines
psi	Pounds per square inch
QAPjP	Quality Assurance Project Plan
QA/QC	Quality assurance/quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RCW	Recirculating Cooling Water
RfC	Reference concentration
RfD	Reference dose

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LIST OF ABBREVIATIONS (continued)

RFI	RCRA Facility Investigation
RME	Reasonable maximum exposure
RSS	Residual sum of squares
RSY	Railroad Spur Yard Storage Area
SASW	Sanitary Sewer System
SF	Slope factor for carcinogens
SIP	Strongly Implicit Procedure
SQL	Sample quantitation limit
SSOR	Slice-successive over-relaxation
STSW	Storm Sewer System
Sunbury	Sunbury Shale
SVOCs	Semivolatile organic compounds
SWMUs	Solid Waste Management Units
TAL	Target Analyte List
Tc	Technetium
TCL	Target Compound List
TE	Typical Exposure
TIC	Tentatively identified compound
TOC	Total organic carbon
UBK	Uptake/Biokinetic Model for lead
UCL	Upper control limit
μg/dl	Micrograms per deciliter
μg/hr	Micrograms per hour
μg/kg	Micrograms per kilogram
μg/l	Micrograms per liter
$\mu g/m^3$	Micrograms per cubic meter

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LIST OF ABBREVIATIONS (continued)

μm	Micrometers
UBK	Uptake/Biokinetic
U.S. DOE	U.S. Department of Energy
U.S. EPA	U.S. Environmental Protection Agency
U.S. FDA	U.S. Food & Drug Administration
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VOCs	Volatile organic compounds
WHO	World Health Organization

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PREFACE

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Polycyclic Aromatic Hydrocarbons (PAHs) contamination at the Portsmouth Gaseous Diffusion Plant have been identified within this report on an individual Solid Waste Management Unit basis. However, determination of specific sources and levels of ecological and human health risk have not been addressed within this report. To obtain this information the reader is referred to the following U.S. Environmental Protection Agency (Region 5) and Ohio Environmental Protection Agency approved document:

U.S. Department of Energy (U.S. DOE). 1997. Risk Management Considerations for Polycyclic Aromatic Hydrocarbon Contamination at the Portsmouth Gaseous Diffusion Plant, Piketon Ohio, DOE/OR/11-140&D2, March 7, 1997.

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EXECUTIVE SUMMARY

The Portsmouth Gaseous Diffusion Plant (PORTS) is owned by the U.S. Department of Energy (U.S. DOE). The production facilities are leased and operated by the U.S. Enrichment Corporation. The facility was formerly operated by Martin Marietta Energy Systems, Inc. (Energy Systems) until July 1, 1993. In 1995, through a corporate merger, Martin Marietta Energy Systems became Lockheed Martin Energy Systems, Inc. Geraghty & Miller, Inc., was retained by Energy Systems in 1988 to conduct a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the PORTS facility as part of the overall RCRA Corrective Action process that is currently ongoing at the site. RCRA Corrective Action is being conducted at the site under requirements and schedules specified in the Consent Decree issued by the Ohio Attorney General's office on August 29, 1989, and the RCRA Section 3008(h) Consent order issued by the U.S. Environmental Protection Agency (U.S. EPA), Region V on September 29, 1989.

As stated in the Ohio Environmental Protection Agency (OEPA) Consent Decree and in the U.S. EPA Consent Order, the purpose of the RFI at PORTS is to acquire, analyze and interpret data that will do the following:

1. Characterize the environmental setting, including groundwater, surface water and sediment, soil, and air.

2. Define and characterize sources of contamination.

3. Characterize the vertical and horizontal extent and degree of contamination of the environment

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4. Assess the risk to human health and the environment resulting from possible exposure to contaminants.

5. Support the Cleanup Alternatives Study/Corrective Measures Study (CAS/CMS), which follows the RFI, if required.

The Quadrant II Phase I RFI was performed in strict accordance with the Quadrant II RFI Work Plan (Geraghty & Miller, Inc., 1990a). The Quadrant II RFI Draft Final Report was submitted to the U.S. EPA and the OEPA in February 1992 (Geraghty & Miller, Inc., 1992a).

The Quadrant II Phase II RFI was performed in strict accordance with the Quadrant II RFI Phase II Work Plan (Geraghty & Miller, Inc., 1994), which was approved by the OEPA in September 1993 and by the U.S. EPA in December 1993. Field work for the RFI was conducted from October 1993 to January 1994. All media except air were investigated during the RFI; the scope of air-related RFI activities has been negotiated with the OEPA and the U.S. EPA. The Air RFI Report is currently being completed. A total of 21 Solid Waste Management Units (SWMUs) were investigated during the Quadrant II Phase I and Phase II RFI at the PORTS facility. During the RFI, surface and subsurface-soil samples, sediment samples, surface-water samples, and groundwater samples recommended in the approved Quadrant II Phase I and II RFI Work Plans were collected as specified in the approved work plan and RFI Sampling Plan (Geraghty & Miller Inc., 1992b). All Phase I and Phase II RFI samples evaluated in this report were analyzed for parameters specified in the approved Quadrant II RFI Work Plan at Savannah Laboratories and at the PORTS Laboratory using analytical methods and Level III data quality objectives (DQOs) described in the approved Quality Assurance Project Plan (QAPjP) (Geraghty & Miller, Inc., 1992c; Energy Systems, 1991) for each laboratory.

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During Phase I and Phase II, comprehensive analyses of soil and sediment samples were conducted at each unit, where applicable, for Target Compound List/Target Analyte List (TCL/TAL) constituents as listed in the U.S. EPA Statement of Work for Organic (1988a) and Inorganic (1988b) Analyses. Surface-water and groundwater samples, where applicable, were analyzed for the Appendix IX list of constituents from RCRA 40 CFR Part 264. Solid and liquid samples were analyzed for fluoride, Freon-113, and radiological parameters (gross alpha, gross beta, total uranium, and technetium). Additional analyses for transuranic elements (neptunium and plutonium) and uranium isotopes (uranium-234, uranium-235, and uranium-238) were performed on a minimum of 5 percent of samples (during Phase I) and on selected Phase II samples, as specified in the approved Quadrant II Phase II RFI Work Plan (Geraghty & Miller, Inc., 1994). During Phase II, additional sampling and analyses were selected to support the risk assessment and the CAS/CMS and also to satisfy the U.S. EPA and the OEPA requirements.

Presented below is a discussion of how the objectives of the RFI (shown in boldface below), as stated in the OEPA Consent Decree and U.S. EPA Consent Order, were achieved; recommendations for further action are also provided where applicable.

- ***Characterize the environmental setting, including groundwater, surface water and sediment, soil, and air.***

The environmental settings of Quadrant II and the PORTS facility are well understood as a result of this and previous investigations. In addition, background levels of naturally occurring constituents have been determined and are specified in the Background Sampling Investigation Report (BSI) (U.S. DOE, 1996). The investigation of one component of the environmental setting, however, is still in progress. The Air RFI field work has been conducted and the report is currently under review.

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- ***Define and characterize sources of contamination.***

Potential sources of contamination were identified during development of the Quadrant II Description of Current Conditions (DOCC) (Geraghty & Miller, Inc., 1990b). Waste Characterization Data Sheets, which include detailed information regarding the physical and chemical properties of potential contaminants associated with these sources, were developed. The nature of operations, structure, and history of waste disposal at each unit were also reviewed to determine the most appropriate type of investigation. During this review, point sources of contamination were identified at seven of the 22 SWMUs investigated. To complete the characterization of these seven SWMUs, sediment, surface-water, and waste-water samples were collected for comprehensive analyses. These seven SWMUs include the following:

X-230J7 East Holding Pond
X-343 Feed & Vaporization Facility
X-633 Cooling Tower Basin
X-700 Basement Sump
X-700CT Chemical & Petroleum Storage Tanks
X-705 Basement Sump
X-720NP Neutralization Pit

Based upon the data presented in this RFI report, it is believed that no further RFI work is warranted at these SWMUs.

- ***Characterize the vertical and horizontal extent and degree of contamination of the environment.***

Contamination of environmental media was identified at 19 of the 22 SWMUs in Quadrant II and at the Quadrant II Investigative Area groundwater contaminant plume. At all of these 19 SWMUs, the nature (constituents and maximum concentrations) and vertical and horizontal extent of contamination were determined. This report concludes that no further RFI work is required in Quadrant II to characterize the extent and degree of contamination.

- ***Assess the risk to human health and the environment resulting from possible exposure to contaminants.***

An evaluation of potential risks to human health associated with each SWMU in Quadrant II was conducted as part of the RFI to support risk-based decisions regarding the need for further action. Risks were evaluated under two scenarios: the hypothetical future-residential-use scenario and the current-use scenario. An individual evaluation of soil and groundwater samples collected from areas adjacent to three SWMUs (Return Cooling Water System, Sanitary Sewer System, and Storm Sewer System) was not performed because of the spatial variation of data associated with these units. However, data from these sampling locations were considered in the overall evaluation of the quadrant and in the evaluations of other SWMUs located near the Return Cooling Water System, Sanitary Sewer System, and Storm Sewer System.

The risk evaluation was performed using tentative background values for metals and naturally occurring radiological parameters that were calculated as part of the Quadrant I/Quadrant II RFIs. (Background concentrations of naturally occurring constituents must be established before risks can be fully evaluated.) Although

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background levels have since been revised and characterized in the BSI, background values for soil and groundwater were not approved until after the assessment of risk for Quadrant II SWMUs had been completed. Therefore, approved background values presented in the BSI are not incorporated into this report. In addition, inorganic constituents and naturally occurring radiological parameters were not evaluated in this report and will be assessed in the CAS/CMS. Risks associated with SWMUs in Quadrant II will be reevaluated after background values are evaluated in the CAS/CMS. If this reevaluation of risk indicates that risk levels associated with a unit are "acceptable," no further action will be proposed at that SWMU; if risk levels are "unacceptable," further action will be proposed. The results of the risk evaluation conducted during this investigation are summarized below.

Based on an analysis of risks associated with a hypothetical future-residential-use scenario and using a set of reasonable maximum exposure (RME) assumptions, SWMUs can be separated into three groups classified according to potential carcinogenic and non-carcinogenic risk. Similarly, SWMUs for which surface-water or sediment data were collected can be separated into risk categories based on a future-recreational-use scenario. Unless otherwise indicated, the following risk categorization is based on soil or groundwater data.

Target Risk Levels Not Exceeded

SWMUs in this group pose negligible carcinogenic risk (less than 10^{-6}) and negligible non-carcinogenic risk (hazard index [HI] less than 1). One SWMU is included in this group:

- X-744 RW Retrievable Waste Storage Area

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Within Target Risk Levels

SWMUs in this group pose carcinogenic risks within the U.S. EPA range of concern (between 10^{-6} and 10^{-4}). Five SWMUs are included in this group:

- X-230J7 East Holding Pond and Oil Separation Basin
- X-343 Feed and Vaporization Facility
- X-701BP Northeast Oil Biodegradation Plot
- X-747G Northeast Contaminated Storage Yard
- Barren Area

Target Risk Levels Exceeded

SWMUs in this group pose a significant carcinogenic risk (greater than 10^{-4}) or significant non-carcinogenic risk (HI greater than 1). Twelve SWMUs evaluated in the RFI are included in this group:

- X-633/RCW Recirculating Water Pump House, Cooling Tower and Quadrant II RCW System
- X-700 Chemical Cleaning Facility
- X-700CT Chemical and Petroleum Storage Tanks
- X-700T Outside Storage Tank
- X-701C Neutralization Pit
- X-705 Decontamination Building
- X-705A/B Radioactive Waste Incinerator, Contaminated Burnables Storage Lot
- X-720 Maintenance Building/Neutralization Pit
- X-744G Bulk Storage Building

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- East Drainage Ditch
- Little Beaver Creek
- Process Waste Lines

Although the X-701B Holding Pond was not investigated during the Phase I and II RFIs, groundwater samples were collected from wells in the vicinity of X-701B. Some of these samples were included in the data sets for other SWMUs adjacent to the unit. Although a risk assessment was not specifically performed for X-701B because the unit was not included in the RFI investigation, it is clear that levels of constituents in groundwater samples collected from within the X-701B plume present an unacceptable risk.

The criteria used to determine whether sufficient data have been collected during the RFI to support the risk assessment are discussed in Section 4.2 (Technical Approach) of this report. Based upon a review using these criteria, sufficient data have been collected to support the risk assessment at all SWMUs investigated.

- Support the CAS/CMS

The results of the RFI provide a foundation for the Quadrant II CAS/CMS reports.. Data regarding the nature and extent of contamination in environmental media, and the environmental setting of the facility (including site geology/hydrogeology and the groundwater flow directions) were collected during the Quadrant II RFI. Geotechnical data including bulk density, grain size analysis, soil permeability, Atterberg limits, standard Proctor analysis, soil porosity, cation exchange capacity, and total organic carbon were collected during the Quadrant I/Quadrant II RFIs Phase I and Phase II conducted in 1991 and 1994. This combination of geologic/hydrogeologic and geotechnical data will be used in the evaluation of

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corrective measure technologies performed as part of the CAS/CMS. A preliminary evaluation of applicable or relevant and appropriate requirements (ARARs) for the PORTS facility was conducted in 1992 (Houlberg et al, 1992). A complete review of ARARs is conducted as part of the CAS/CMS.

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Geraghty & Miller, Inc., June 1992c. Laboratory QAPjP for the RCRA Facility Investigation at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, RFI General Plan-Volume II.

Geraghty & Miller, Inc., January 1994. Quadrant II RCRA Facility Investigation Phase II Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio.

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Martin Marietta Energy Systems, Inc. 1991. Laboratory QAPjP for the RCRA Facility Investigation at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, RFI General Plan-Volume III, February 1991.

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1.0 INTRODUCTION

1.1 Background

The Portsmouth Gaseous Diffusion Plant (PORTS) is owned by the U.S. Department of Energy (U.S. DOE). The production facilities are leased and operated by the United States Enrichment Corporation. The facility was formerly operated by Martin Marietta Energy Systems (Energy Systems) until July 1, 1993. In 1995, through a corporate merger, Martin Marietta energy Systems became Lockheed Martin Energy Systems, Inc. Geraghty & Miller, Inc., was retained by Energy Systems to conduct a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the PORTS facility as part of the overall RCRA Corrective Action process, that is currently ongoing at the site. RCRA Corrective Action is being conducted at the site under requirements and schedules specified in the Consent Decree issued by the Ohio Attorney General's office on August 29, 1989, and in the RCRA Section 3008(h) Consent Order issued by the U.S. Environmental Protection Agency (U.S. EPA), Region V on September 29, 1989.

The PORTS facility is located near Piketon, Ohio, in the south-central portion of the state. The active plant site (the PORTS facility) encompasses approximately 1,000 acres of the 3,714-acre U.S. DOE reservation (reservation). The principal process at the PORTS facility is the separation of uranium isotopes via gaseous diffusion. The PORTS facility has been operating since 1954, enriching uranium for use in commercial nuclear reactors. Support operations include the feed and withdrawal of material from the primary process, water treatment for sanitary and cooling purposes, decontamination of equipment removed from the plant for maintenance or replacement, recovery of uranium from various waste materials and treatment of sewage wastes and cooling water blowdown. The construction, operation and maintenance of this facility require the use of a wide range of commercially available chemicals. Continuous operation of the plant since 1954 has resulted in the generation of inorganic, organic, and low-level radioactive waste materials.

As discussed in detail in the Quadrant II Description of Current Conditions (DOCC) (Geraghty & Miller, Inc., 1990a), the PORTS facility has been separated into four quadrants. Each quadrant (see Section 2.0 [Characterization of Environmental Setting]) roughly corresponds to a distinct groundwater flow cell within the primary water-bearing unit beneath the site and has been investigated separately. The Quadrant II RFI Phase II was performed in strict accordance with the Quadrant II RFI Work Plan (Geraghty & Miller, Inc. 1990b) and the Quadrant II Phase II RFI Work Plan (Geraghty & Miller, Inc., 1993), which were approved by the Ohio Environmental Protection Agency (OEPA) and the U.S. EPA on February 19, 1990, and September 20, 1993, respectively. Field work for Phases I and II of the RFI was conducted from February to August 1990 and from October to December 1993, respectively. Sampling locations associated with the Quadrant II RFI Phase II are presented in Plate I (Appendix A). All media except air were investigated during the RFI; the scope of air-related RFI activities has been negotiated with the OEPA and the U.S. EPA and is currently ongoing with a deliverable date of November 1, 1996.

1.2 Purpose of This Investigation

As stated in the OEPA Consent Decree and in the U.S. EPA Consent Order, the purpose of the RFI at PORTS is to acquire, analyze, and interpret data that will do the following:

1. Characterize the environmental setting, including surface water and sediment, groundwater, soil, and air.

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2. Define and characterize sources of contamination.

3. Characterize the vertical and horizontal extent and degree of contamination of the environment.

4. Assess the risk to human health and the environment resulting from possible exposure to contaminants.

5. Support the Corrective Measures Study (CMS), which will follow the RFI, if required.

1.3 Conceptual Approach to RCRA Corrective Action

The conceptual approach to the RCRA Corrective Action process in the Quadrant II RFI Phase II is summarized on Figure 1.1. The first step in the process was to identify solid waste management units (SWMUs) where the potential for a release was present or where the U.S. EPA Consent Order or OEPA Consent Decree required further action. The primary focus of the RFI was to determine if releases to the environment have occurred from SWMUs and to collect data to support an evaluation of risk for each SWMU and for the quadrant. If a release to the environment was found, an attempt was made to determine the nature and extent of the contamination sufficiently to support an evaluation of risk. In cases where the nature and extent of contamination were not sufficiently determined, additional investigation is recommended.

An evaluation of risks associated with each SWMU was performed using tentative background values calculated during the Quadrant I/Quadrant II RFIs. (Background concentrations of naturally occurring constituents must be established

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before risks can be fully evaluated.) Risks associated with SWMUs in Quadrant II will be reevaluated after background values are established. If this reevaluation of risk indicates that risk levels associated with a unit are "acceptable," no further action will be proposed at that SWMU; if risk levels are "unacceptable," further action will be proposed.

This report presents a description of site conditions and identifies potential contaminants and primary pathways for releases at each SWMU. A summary of the investigation performed at each SWMU and of the results of each investigation is presented. The results for each SWMU are discussed in detail to determine if the objectives of the RFI have been achieved. Conclusions regarding the RFI and recommendations for further action at selected SWMUs are also included.

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1.4 References

Geraghty & Miller, Inc., 1990a. Quadrant II Description of Current Conditions for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio.

Geraghty & Miller, Inc., 1990b. Quadrant II RCRA Facility Investigation Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio.

Geraghty & Miller, Inc., 1993. Quadrant II RCRA Facility Investigation Phase II Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio.

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2.0 CHARACTERIZATION OF ENVIRONMENTAL SETTING

The characterization of the environmental setting is discussed below in terms of physiographic setting and site geology and hydrogeology. Detailed discussions regarding groundwater flow in each of the four quadrants of the PORTS facility are also provided.

2.1 Physiographic Setting of the PORTS Facility

The PORTS facility is located within the Appalachian Plateau physiographic province approximately 20 miles south of the limit of glaciation in Ohio (Feneman, 1938). As a result, the geologic setting of the site has been heavily influenced by drainage associated with glacial events. The PORTS facility occupies an upland area of Southern Ohio with an average land surface elevation of 670 feet above mean sea level (msl) (Plates I and II in Appendix A). The terrain surrounding the plant site consists of marginal farmland and wooded hills, generally with less than 100 feet of relief. As shown on Figure 2.1, the plant is located within a mile-wide abandoned river valley situated 130 feet above the level of the Scioto River Valley, which lies approximately 1 mile to the west.

2.2 Geology of the PORTS Facility

The geology of the PORTS facility has been characterized through the drilling of over 1,200 borings throughout the site. The near-surface geologic materials that influence the hydrologic system at the PORTS facility comprise two general classes: the sandstone and shale bedrock formations of the Bedford Shale (Bedford), the Berea Sandstone (Berea), the Sunbury Shale (Sunbury), and the Cuyahoga Shale (Cuyahoga); and the unconsolidated deposits of silt, clay, sand, and gravel comprising the Minford

Clay and Silt (Minford) and the Gallia Sand and Gravel (Gallia). Both classes of geologic material and the recent geologic history are discussed below in detail.

Prior to the Pleistocene glaciation, the Teays River and its tributaries were the dominant drainage systems in Ohio. The Teays River originated in the Piedmont region of Virginia and North Carolina and entered Ohio from the south in Scioto County. The Teays River flowed southeast to northwest passing approximately 3 miles north of the location now occupied by the PORTS facility (Figure 2.1). In the vicinity of the PORTS facility, the location of the ancient Teays River Valley, currently occupied by Big Beaver Creek, is easily visible on topographic maps. The Portsmouth River, a tributary of the Teays, flowed north across the plant site location between bluffs of Cuyahoga Shale. The Portsmouth River downcut through the Cuyahoga and into the Sunbury Shale and Berea Sandstone Formations and deposited fluvial silty sands and gravels of the Gallia member of the Teays Formation (Figures 2.1 and 2.2).

Approximately one million years ago, a glacier advancing from the north blocked the northwestward flow of the Teays River. This event resulted in the creation of Lake Tight, which filled the valleys of the Teays River and its tributaries, including the Portsmouth River. Lacustrine silt and clay (Minford), indicative of low-energy conditions, were deposited on the lake bottom overlaying the meandering stream deposits that constitute the Gallia. The basal 10 to 15 feet of the Minford commonly consist of relatively clean silt (Figure 2.3), perhaps reflecting shallow lake levels and reworked sediment or possibly Portsmouth River over-bank deposits. Above this silt layer lies a series of laminated clays that may represent sediments deposited as glacial Lake Tight grew deeper and more extensive.

Eventually, Lake Tight overflowed its banks and initiated the high volume and high energy lower elevation drainage paths known as Deep Stage drainage. The most significant Deep Stage stream in southern Ohio was the south-flowing Newark River (Figure 2.4). The Newark River occupied the former Teays River Valley from Chillicothe to Waverly, bypassed the area of the PORTS facility, then occupied the former Portsmouth River Valley south to Portsmouth. As the glaciers retreated, meltwater flowed down the Newark River Valley, partially backfilling it with outwash. The present-day Scioto River flows in this valley on top of a thick layer of outwash.

2.2.1 Bedrock Geology

Mississippian age clastic sedimentary rocks underlie the unconsolidated sediments beneath the PORTS facility to depths of approximately 30 to 45 feet (Plates III, IV, and V in Appendix A). The oldest bedrock formation encountered during environmental investigations at the site is the Bedford Shale. In stratigraphic sequence from the Bedford Shale, younger bedrock formations present at the PORTS facility include the Berea Sandstone, the Sunbury Shale, and the Cuyahoga Shale. A general stratigraphic column at the PORTS facility is shown on Figure 2.3. A lithologic fence diagram from Quadrant II is presented on Plate IV (Appendix A). A detailed discussion of each of these bedrock formations encountered at the PORTS facility is presented below.

The Bedford Shale is the lowest stratigraphic unit encountered during environmental investigative activities at the site. The typical depth to the top of this formation at the PORTS facility is 70 to 100 feet below ground surface. The Bedford Shale averages 100 feet in thickness and is composed of thinly bedded shale with interbeds and laminations of gray, fine-grained sandstone, and siltstone. Sandstone interbeds predominate at the top of the Bedford, but decrease in frequency with depth. The Bedford Shale acts as a lower confining unit for the Berea Sandstone above.

The Berea Sandstone is a light gray, thickly bedded, fine-grained sandstone with scattered thin shale laminations. The Berea averages 30 feet in thickness; however, the lower 10 feet has numerous shale laminations and is very similar to the underlying Bedford Shale. This gradational contact, therefore, does not allow for a precise determination of the thickness of the Berea. Regionally, the Berea Sandstone is used for production of oil and gas; however, near the PORTS facility, the Berea is the uppermost water-bearing bedrock unit. The Berea is the uppermost bedrock unit beneath the western portion of the PORTS facility, but is overlain by the Sunbury Shale to the east.

The Sunbury Shale is a black, very carbonaceous shale. In outcrop, the Sunbury is fissile and highly fractured; however, in cores obtained during bedrock drilling at the PORTS facility, the Sunbury has been found to be coherent, semi-plastic and clayey. A thin (1- to 3-inch) zone of sulfide mineralization occurs locally at the contact between the Sunbury and the underlying Berea. The Sunbury ranges in thickness from 0 to 20 feet beneath the PORTS facility. The Sunbury thins westward due to erosion by the Portsmouth River and is absent on the western half of the site (Plate V in Appendix A). It is also absent in the drainage of Little Beaver Creek (LBC), where it has been removed by recent erosion. Due to erosion and subsequent deposition during formation of the Portsmouth River Valley, the Sunbury Shale underlies the unconsolidated Gallia beneath the eastern portion of the plant (Figure 2.2) and the Cuyahoga Shale outside of the Portsmouth River Valley.

The Cuyahoga Shale, the youngest and uppermost bedrock unit at the site, forms the hills surrounding the plant. The Cuyahoga does not directly underlie the active portion of the PORTS facility due to the local erosional patterns (Figure 2.2). The Cuyahoga consists of gray, thinly bedded shale with scattered lenses of fine-grained sandstone and reaches a local thickness of approximately 160 feet.

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2.2.2 Unconsolidated Sediments

Unconsolidated sediments in the vicinity of the PORTS facility fill the ancient Portsmouth River Valley to depths of approximately 30 to 40 feet below ground surface. The unconsolidated sediments are divided into two members of the Teays Formation, including the Minford Clay and Silt and the Gallia Sand and Gravel. Both of these members are discussed below in detail beginning with the underlying Gallia.

2.2.2.1 Gallia Sand and Gravel

Prior to Pleistocene glaciation, the Portsmouth River meandered north through the valley currently occupied by the PORTS facility depositing the sand and gravel of the Gallia. A contour map of Gallia thickness, developed from over 1,100 data points, is presented on Plate VI (Appendix A). The areas of thickest accumulation of Gallia shown on this plate may represent the channel location just prior to formation of Lake Tight. The ancient channel extends from the south near Big Run Creek northward along the eastern side of the valley, then curves to the west under the southern end of the X-330 building and continues north along the western side of the valley (Plates III and VI in Appendix A). A meander valley of the Portsmouth River was cut through the Cuyahoga Shale to the east of the site, as shown on Figure 2.1. Sporadic, thick Gallia deposits are present where this secondary meander valley intersects the main valley near X-701B.

The Gallia averages 3 to 4 feet in thickness at the site and is characterized by poorly sorted, silty, clayey medium to coarse sand or gravel with the primary constituent varying between sand and gravel. (Law Engineering Testing Company [1978] indicated that the Gallia had an average clay content of 30 percent.) Channel migration and variability in depositional environments that occurred during deposition of the Gallia have resulted in variations in the thickness of the Gallia. Localized thick and thin areas of the Gallia within the perimeter road are the result of migration of the Portsmouth River channel and associated deposition and/or erosional scour (Plate VI in Appendix A). Valley walls that enclosed the ancient Portsmouth River formed a natural barrier for deposition of Gallia channel deposits. Gallia deposits are generally absent above an approximate elevation of 670 feet msl along the valley walls.

Due to similar depositional environments and source material, stream deposits from modern streams at the site are often visually indistinguishable from Gallia deposits. This similarity may have, in some cases, resulted in an overestimation of Gallia thickness. Relatively thick Gallia deposits near the X-734 landfill and possibly near the Old Firing Range may be the result of this indistinguishable mixture of modern and ancient channel deposits. Likewise, the modern surface-water drainage system has also dissected the Gallia, resulting in thin Gallia deposits where downcutting has removed the overlying Minford and portions of the Gallia. The combination of post-Gallia erosion and modern stream deposition over already variable Gallia thickness has resulted in irregular thicknesses across the site.

2.2.2.2 Minford Clay and Silt

The Minford is the uppermost stratigraphic unit beneath the PORTS facility. The Minford averages 20 to 30 feet in thickness at the PORTS facility (Plate VII in Appendix A), grading from predominantly silt and very fine sand at its base to mostly clay near the surface. The upper clay unit averages 16 feet in thickness, is reddish-brown, silty, and plastic and contains traces of sand in some locations. However, at Quadrant III, the Minford reaches thicknesses of as great as 30 feet (Plate VII in Appendix A). As discussed below, these thicknesses may be somewhat exaggerated due to construction filling operations. The lower silt unit averages 7 feet in thickness, is yellow-brown, and semi-plastic and contains varying amounts of clay and very fine sand. The contact between silt and clay is gradational. A study by Law Engineering Testing Company (1978) estimated that silt content in the Minford as a whole is approximately 33 percent.

Soil, colluvium and recent alluvium are present in varying amounts at the surface near the PORTS facility. It is significant, however, that during the initial grading of the site, prior to plant construction, as much as the upper 20 feet of the deposits within the perimeter road were reworked by pre-construction cut and fill activity and locally replaced with disturbed Minford or fill material. The fill in many locations consists predominantly of Minford clay and silt removed from high areas and relocated to low areas (Figure 2.5). In most cases the fill is indistinguishable from the undisturbed Minford; however, maps showing pre-construction topography indicate some areas of thick fill.

Variations in bedrock topography that existed before construction of the PORTS facility and downcutting by modern streams have also had a significant effect on the thickness of the Minford deposits. The Minford is thinnest where it overlies topographic highs that existed before the construction of the PORTS facility. Around the perimeter of the PORTS facility, the Minford thins and finally pinches out at the contact with the bedrock valley walls that enclosed Lake Tight. Minford deposits are generally absent above an elevation of 685 feet msl along the valley walls. The Minford also thins where surface-water drainages have eroded the lacustrine sediments of the Minford. In summary, the combination of construction activities, existing bedrock topography and downcutting by modern streams has influenced the areal extent and thickness of the Minford at the PORTS facility.

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2.2.3 Geologic Structure

The geologic structure of the area is very simple, with the Mississippian strata (Cuyahoga, Sunbury, Berea, and Bedford) dipping gently to the east-southeast at approximately 30 feet per mile (0.3 degree). There are no significant geologic faults in the area; however, two distinct joint sets (N65°E and N25°W) are visible in outcrops of the Sunbury, Berea, and Bedford Formations. Bedding-plane fractures are also present in the bedrock formations.

The occurrence of bedrock outcrops at the PORTS facility is governed by regional dip of the bedrock units, erosion caused by the modern surface-water drainage systems and the location of natural bedrock highs. The regional eastern dip of bedrock units results in subcrop of the Sunbury Shale beneath the PORTS facility. The Sunbury thins from approximately 20 feet at the eastern margin of the site to a zero thickness in the center of the site (Plate V in Appendix A). This thinning and erosional subcrop of the Sunbury causes unconsolidated sediments in the western half of the site to be underlain by the older Berea Sandstone, while the eastern half of the site is underlain by the Sunbury Shale. These differences in bedrock lithology are largely responsible for the difference in hydrogeologic properties between the eastern and western sections of the PORTS facility.

Bedrock highs that pre-date deposition of the unconsolidated sediments are also responsible for bedrock outcrop patterns at the PORTS facility. Bedrock outcrops, consisting of the Sunbury Shale and the overlying Cuyahoga Shale, are present along the valley walls that enclosed the Portsmouth River and Lake Tight. Localized bedrock highs often result in bedrock outcrops around the perimeter of the PORTS facility. These bedrock highs are probably the result of differential erosion and early establishment of the Portsmouth River system.

Erosion by the modern surface-water drainage system is also responsible for bedrock outcrops at the PORTS facility (Figure 2.6). Unconsolidated Minford and Gallia deposits have been reworked and eroded by modern streams, resulting in exposure of the Sunbury Shale, Berea Sandstone, and Bedford Shale in low topographic areas. These outcrops are generally limited to narrow exposures within the valleys of the drainage systems. In summary, a combination of regional bedrock dip, localized bedrock highs, and modern stream erosion is responsible for the bedrock outcrop patterns observed at the PORTS facility.

2.3 Hydrogeology of the PORTS Facility

The groundwater flow system at the PORTS facility includes two aquifers (the bedrock Berea Sandstone and the unconsolidated Gallia) and two aquitards (the Sunbury Shale and the unconsolidated Minford) (see Figure 2.3). The basal silt portion of the Minford is generally grouped with the Gallia to form the uppermost and primary aquifer at the facility. As discussed below, the hydraulic properties of these units have been well defined during previous investigations at the facility. Groundwater flow at the site has also been well defined as a result of this and previous investigations. Groundwater flow maps for the Gallia and the Berea Sandstone are presented on Plates VIII and IX (Appendix A), respectively. The groundwater elevation measurements used to develop these maps are in Table 2.1.

2.3.1 Hydraulic Properties

Several single-well aquifer tests were performed by Geraghty & Miller in 1989 (Geraghty & Miller, Inc., 1989a) at the PORTS facility to estimate the hydraulic conductivity of the Berea (the lowermost aquifer). Measured hydraulic conductivity values of the Berea ranged from 4.5×10^{-3} to 15 feet per day (ft/d) with a mean value

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of 0.16 ft/d. The arithmetic mean of hydraulic conductivity measurements in the Berea at X-616 (where the Sunbury is absent and the Berea may be eroded and weathered) was 0.35 ft/d. The general range for hydraulic conductivity of sandstones is 3.0×10^{-5} ft/d to 30 ft/d (deMarsily, 1986). Although two joint sets have been measured at the PORTS facility (N65°E and N25°W), significant secondary permeability in the Berea Sandstone has not been noted in previous investigations at the site.

The hydraulic conductivity of the Gallia, as determined by single-well tests across the entire PORTS facility, varies from 0.11 to 150 ft/d with an arithmetic mean value of 3.4 ft/d. At the X-616 unit, the arithmetic mean of hydraulic conductivity measurements was 1.2 ft/d. A short-term test performed by Geraghty & Miller (1986a) in the vicinity of X-749 gave a hydraulic conductivity for the Gallia of 1.8 ft/d. Multiple-well aquifer tests were performed at X-701B and X-231B (Quadrant I) by Geraghty & Miller (1990a, 1991) to estimate hydraulic properties of the Gallia. Based on an average thickness of 5 feet, estimated hydraulic conductivity values in the Gallia ranged from 24 ft/d to 104 ft/d at X-701B, with arithmetic mean and median values of 49 ft/d and 44 ft/d, respectively. The X-231B test yielded values between 6.8 ft/d and 62 ft/d, with an arithmetic mean, median, and geometric mean values of 38 ft/d, 40 ft/d, and 31 ft/d, respectively. At X-749 and X-120, slug tests have yielded hydraulic conductivity values of 0.5 ft/d to 57 ft/d in the Gallia. Two pump tests were also performed as part of recent field investigations carried out at the X-749/X-120 area. These tests showed that the hydraulic conductivity of the Gallia ranged from 1.9 ft/d to 8.1 ft/d in the southern portion of the X-749 plume (HAZWRAP, 1993). The hydraulic conductivity of the Gallia is generally higher in areas of thicker accumulation. The storage coefficient for the Gallia also varies considerably at the facility, ranging from 0.00011 to 0.41 with an arithmetic mean of 0.16 (Geraghty & Miller, Inc., 1989a).

Numerous laboratory measurements of hydraulic conductivity for the Minford clay and silt units were performed by Law Engineering Testing Company (1982). The average permeability of the Minford Clay was 2.3×10^{-4} ft/d. The average permeability of the Minford Silt was 4.3×10^{-3} ft/d (Law Engineering Testing Company, 1982). Laboratory analysis of two Minford silt and clay cores collected in the X-701B area (Quadrant II) by Geraghty & Miller (1986b and 1992) yielded vertical hydraulic conductivity estimates of 2.16×10^{-5} ft/d and 1.3×10^{-4} ft/d. Geraghty & Miller (1989a) performed a single-well aquifer test in the Minford at the X-616 unit (Quadrant III), which yielded a hydraulic conductivity value of 0.62 ft/d. Based upon these low hydraulic conductivity values, the Minford clay is considered to be an effective aquitard.

2.3.2 Groundwater Recharge and Discharge Areas

Groundwater recharge and discharge areas at the PORTS facility include both natural recharge and discharge areas and man-made recharge and discharge areas. Both types are discussed in detail in the following sections.

2.3.2.1 Natural Recharge and Discharge Areas

The primary source of recharge to the hydrogeologic flow system at the PORTS facility is from precipitation. Net recharge, the amount of water available for infiltration, has been previously estimated to range between 8.9 and 13.9 inches per year using the empirical Thorthwaite method (Geraghty & Miller, Inc., 1989b, 1990b). However, direct infiltration from precipitation is probably less than that cited above because the continuity and low permeability of the Minford, especially the uppermost clay unit, reduce infiltration into the groundwater flow system. Where the clay unit of the Minford is thin to absent, recharge in the range cited above is more likely. However, in other parts of the facility, recharge could be as low as 2 to 4 inches per year, which is the average for this part of Ohio (Pettyjohn and Henning, 1979). Law Engineering Testing Company (1982) estimated net recharge to the Gallia for two scenarios: 0.1 inch per year where approximately 11 feet of clay existed and 3.9 inches per year where approximately 5 feet of silty clay existed. Generally, it can be assumed that little recharge to the Gallia occurs where the Minford clay unit is greater than 10 feet thick. Buildings and paved areas also further reduce infiltration to the Gallia groundwater flow system. A minimal volume of recharge occurs via lateral inflow from off-site portions including the uplands surrounding much of the site.

Recharge to the Berea flow system is limited by the presence (or absence) of the confining Sunbury Shale. The main recharge area for the Berea in the vicinity of PORTS is just west of the X-326 Process Building where the Sunbury Shale is absent (Plate IX in Appendix A).

Groundwater at the PORTS facility discharges primarily to surface streams, to the extensive storm drain network, and to many of the ponds and lagoons onsite. LBC is a local discharge area for all geologic units in the northern and northeastern portions of the site. Along the western boundary of the site, the West Drainage Ditch serves as a local discharge area for all geologic units. Groundwater in the southern portion of the facility discharges to Big Run Creek and to the Southwest Unnamed Drainage. All of these surface-water units greatly influence groundwater flow directions in the part of the facility where they are located (Plates VIII and IX in Appendix A).

2.3.2.2 Man-Made Recharge and Discharge Areas

Groundwater recharge and discharge areas at the PORTS facility are affected by numerous man-made site features: the storm sewer system, sanitary sewer system, return cooling water (RCW) system and building sumps. The site storm sewer system consists of numerous large-diameter culverts and pipes that drain surface water from discrete segments of the site. The drain system and backfill in which the drains are constructed probably act as interceptor trenches in the Minford and, in certain areas, within the Gallia. Based upon a review of groundwater flow data, this system does not appear to have a significant effect on groundwater flow in the Gallia. Groundwater collected by these drains is transported to the discharge point for each storm drain. Discharge points for the storm drains generally coincide with site National Pollutant Discharge Elimination System (NPDES) outfalls that eventually discharge to the surface-water units described above.

Two other systems of underground lines that may affect groundwater flow at the PORTS facility are the RCW system and the sanitary sewer system. Both of these systems of underground lines are generally located within 10 to 12 feet of the ground surface. Consequently, both systems and the backfill associated with the systems are usually located above the local water table. The RCW system is also pressurized to ensure proper transport of return cooling water. Because of these factors, neither of these systems appears to act as a major discharge area for groundwater. Because the RCW system is pressurized, it could be a source of recharge to groundwater. However, based upon existing groundwater flow data, recharge from these lines to groundwater appears to be insignificant. RCW basins associated with the X-633 cooling towers (Quadrant II) do appear to be sources of groundwater recharge. This recharge is apparent from relatively high groundwater levels, measured in the immediate vicinity of the basins, which indicate the presence of small groundwater mounds (Plate VIII in Appendix A). The RCW basin associated with the X-626 Cooling Tower (Quadrant I) does not impact the groundwater in this area.

One major man-made feature that significantly affects groundwater flow at the site is a set of building sumps located in the X-700 and X-705 buildings. Sumps in these buildings are pumped at an average rate of 25,000 gallons per day (gpd) in order to keep the basements dry. This pumpage has a significant effect on groundwater flow because it creates a large cone of depression that is centered around the active sumps. The Sunbury Shale also thins or may be absent in this area. Vertical gradients in the area indicate possible upward flow from the Berea to the Gallia. Based upon existing groundwater flow data, no other building sumps appear to have a significant effect on groundwater flow at the PORTS facility.

2.3.3 Groundwater Flow

Groundwater flow directions and gradients at the PORTS facility are influenced by complex and numerous interactions between the hydrogeologic units, natural surface drainages and man-made features at the site. Interactions between hydrogeologic units include variable communication between the Gallia, Sunbury, and Berea and between the Gallia and Minford. Groundwater flow directions in the Gallia and Berea are similar across the site with upward and downward gradients between the units. Local groundwater flow in these units is strongly influenced by natural drainage features (LBC, Big Run Creek, the West Drainage Ditch, and the Unnamed Southwest Drainage) and to a lesser extent, man-made drainage features (storm sewer systems) that act as discharge areas.

As shown on Plate VIII (Appendix A), groundwater flow at the site can generally be divided into four separate flow regions separated by small groundwater divides. These groundwater divides provided the basis for separation of the reservation into quadrants for RFI purposes; the quadrant boundaries generally parallel the flow divides. Of all the variables affecting groundwater flow direction, surface-water drainage at the site exhibits the greatest influence. Groundwater in the Gallia in each flow region ultimately discharges to a surface-water drainage. The interaction between recharge areas and surface-water drainages ultimately controls the location of the various groundwater flow divides in the Gallia. Other less important factors affecting the locations of the divides include seasonal changes in precipitation and pumping from sumps in the X-700/X-705 buildings. The effect of either of these factors on the location of the groundwater flow divides is minor compared to the effect of the site surface-water drainage system. Groundwater flow divides migrate slightly depending upon seasonal changes in precipitation that lead to changes in the amount of groundwater recharge. The flow divides migrate toward areas that receive a larger amount of recharge from precipitation. These areas include locations in which the Minford Clay or extensive surface paving and/or buildings are absent. Pumping of sumps in the X-700/X-705 area causes flow divides to migrate away from this area as pumping increases. These changes in the location of the divides occur as the groundwater flow system at the site develops dynamic equilibrium.

2.3.3.1 Quadrant I - Southern Flow Region

The direction of groundwater flow in the southern portion of the facility (Quadrant I) is controlled by the presence of surface drainages (Big Run Creek and the Unnamed Southwest Drainage), the storm sewer system, and bedrock topography. In general, groundwater in the Gallia flows from north to south, discharging into either Big Run Creek or the Unnamed Southwest Drainage (Plate VIII in Appendix A). Groundwater in the Gallia in the south-central portion of the site (near X-231B) flows primarily to the southeast toward the X-230K Holding Pond. The hydraulic gradient is very low because of the flat valley floor, the presence of thicker, more permeable Gallia deposits, and the proximity to the east-west groundwater divide that runs through the facility. Storm drains have been observed to affect the local flow system at X-231B (Geraghty & Miller, Inc., 1989a). The vertical gradient from the Gallia to the Berea is steep, with an average difference of 8 to 10 feet near X-231B. The vertical gradient decreases to the west as the Sunbury thins.

The groundwater flow system near X-749 exhibits minor north-south divides in both the Gallia and Berea (Plates VIII and IX in Appendix A). The divide in the Gallia runs near the western boundary of the landfill. Groundwater flows away from the divide to the east toward Big Run Creek and to the west toward the Unnamed Southwest Drainage. The storm sewers associated with the Gaseous Centrifuge Enrichment Process (GCEP) area influence groundwater flow along the western edge of Quadrant I. A bedrock high located south of the southern edge of the plant site causes groundwater to flow in an east-west direction in this area. Groundwater gradients are steep along Big Run Creek because of the presence of sediment with low conductivity and the rapid drop in elevation toward the creek. The vertical component of flow is downward into the Berea with a difference in Gallia and Berea water levels ranging from 10 to 15 feet. Groundwater flow directions in the Berea in the area are very similar to the directions observed in the Gallia. The north-south groundwater divide occurs farther west in the Berea than in the Gallia, with flow to the east toward Big Run Creek and to the west towards the Unnamed Southeast Drainage.

2.3.3.2 Quadrant II - Eastern Flow Region

Groundwater flow in the eastern flow region (Quadrant II) is influenced by such factors as the presence and absence of Sunbury Shale, Little Beaver Creek, holding ponds, and drainage ditches, bedrock topography, building sumps, and Minford Clay thickness. Little Beaver Creek is the local surface-water receptor for shallow groundwater flow in the area. Much of the groundwater in the Minford and Gallia along the eastern portion of the site migrates toward the creek. The storm sewer system in the area is typically completed within the Minford. The impact of this

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system, as well as the sanitary sewer and RCW systems, on local groundwater flow direction appears to be limited in this area.

Groundwater flow directions in both the Minford and the Gallia are affected by the presence of drainage ditches and holding ponds, the most prominent in the area being the X-230J7 Holding Pond and East Drainage Ditch (Plate VIII in Appendix A). Both the holding pond and drainage ditch were excavated to bedrock causing seepage faces to develop where the water table intersects the land surface along the side walls in both the Minford and the Gallia. As a result, groundwater near the holding pond and drainage ditch converges toward these local discharge areas.

Groundwater flow in the Berea in this area is primarily east to northeast. The flow direction in this area results from the increased communication between the Gallia and Berea due to the thinning or absence of the Sunbury along the western portion of the site. In most areas, the flow is downward from the Gallia to the Berea. Vertical hydraulic gradients between the Gallia and Berea are greatest where the Sunbury is a thick, competent shale. Groundwater flow through the Sunbury is assumed to be essentially vertical. Near the X-705/X-700 buildings where the Sunbury is thin or absent, vertical gradients indicate possible upward flow from the Berea to the Gallia. However, sumps located in the basement at the X-705 building pump at an average rate of 25,000 gpd. This pumpage has a significant effect on groundwater flow because it creates a cone of depression centered around the active sumps.

Paved areas, buildings, and thick upper Minford clay and Sunbury Shale deposits effectively reduce recharge to underlying units throughout the PORTS facility. West of X-701B, recharge is reduced to the Minford and Gallia because a large percentage of the land is paved or covered by buildings. This combination causes water levels to be lower in the Minford and Gallia in this area (Plate VIII in Appendix A).

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The bedrock highs bordering the northeastern and southeastern portions of the site maintain steep gradients into the main valley. The steep gradients on the northern boundary are also believed to result partially from leakage from the X-633 cooling towers located in this area. This interpretation is supported by water-level measurements taken near the cooling tower basins. These measurements indicate a slight groundwater mound.

2.3.3.3 Quadrant III - Western Flow Region

Groundwater flow in the western flow region (Quadrant III) is influenced by such factors as the presence or absence of the Sunbury, storm drains, holding ponds, and drainage ditches, bedrock topography, buildings, paved areas and the thickness of the clay portion of the Minford. The West Drainage Ditch is the local surface-water receptor for groundwater in the area. As a result, much of the groundwater in the Minford and Gallia in the area migrates to the west and eventually discharges to the upper tributaries of the ditch. Storm drains in the area are typically completed within the Minford. The impact of the drains on local groundwater flow appears to be limited in the area.

The flow directions in the Minford and Gallia are affected by the presence of drainage ditches and holding ponds, the most prominent in Quadrant III being the X-2230N Holding Pond and the West Drainage Ditch. The West Drainage Ditch is deeply incised into bedrock, especially west of the perimeter road, intercepting much of the groundwater in the Minford and Gallia flowing west of the perimeter road. Seepage faces develop where the water table intersects the land surface along the side walls of the ditches in both the Minford and Gallia. Groundwater near drainage ditches and holding ponds converges toward these local discharge areas (Plate VIII in Appendix A).

Although regional groundwater flow in the Berea Sandstone is northwest to southeast, along the western portion of Quadrant III, the direction of groundwater flow in the Berea has been altered by the West Drainage Ditch and by the erosion of the Berea by the Scioto River Valley to the west. In this area, groundwater flow is primarily to the west. The thinning and absence of the Sunbury along the western portion of the site, including much of Quadrant III, increases communication between the Gallia and the Berea; in most areas the flow is downward from the Gallia to the Berea. Vertical hydraulic gradients between the Gallia and Berea are greatest where the Sunbury Shale is thickest.

Land use and the presence of thick upper Minford clay deposits and Sunbury Shale effectively reduce recharge to underlying units. Along the eastern portion of Quadrant III, recharge to the Minford and Gallia is reduced because a large percentage of the land is paved or covered by buildings. However, recharge to the Berea from the overlying Gallia is increased due to the absence of the Sunbury Shale. The recharge area for the Gallia is located east of the West Drainage Ditch (Plate VIII in Appendix A). The recharge area for the Berea is located east of X-616; this area is depicted as a groundwater mound on Plate IX (Appendix A). The bedrock valley walls bordering the western portion of Quadrant III are composed of shale and, therefore, contribute little groundwater recharge to the area.

2.3.3.4 Quadrant IV - Northern Flow Region

Groundwater flow in the northern portion of the facility (Quadrant IV) is strongly controlled by the presence of surface drainages and bedrock highs: Little Beaver Creek, the North Drainage Ditch and, to a lesser extent, the Northeast Drainage Ditch. Little Beaver Creek is the surface-water receptor for groundwater in the Gallia and Berea in the area (Plates VIII and IX in Appendix A). Groundwater flow in the Gallia in the south and southeastern portion of Quadrant IV are strongly controlled by an east-west groundwater flow divide that roughly parallels the Quadrant IV boundary. The divide is very prominent in the south along the Quadrant II/Quadrant IV boundary near a bedrock high of Cuyahoga Shale northeast of the X-633 cooling tower system (Plates III and IV in Appendix A). The unconsolidated groundwater potentiometric surface forms a mound in this area, with steep gradients and radial flow outward toward Little Beaver Creek, the North Drainage Ditches, and the Northeast Drainage Ditch (Plate VIII in Appendix A). This groundwater mound is due primarily to the bedrock high but may also be the result of leakage from the X-633 cooling tower basins in this area.

In the northern portion of Quadrant IV, groundwater in the Gallia (near the X-735 landfill) flows south and southwest toward Little Beaver Creek. The hydraulic gradient becomes steeper near Little Beaver Creek and the North Drainage Ditch where they have cut through the Gallia. Groundwater flow in the northwestern portion of Quadrant IV, in the vicinity of the X-734 landfill, is northeast toward the North Drainage Ditch and Little Beaver Creek. Gradients in both the Gallia and Berea steepen toward these surface-water discharges where the units intersect the land surface along the sides of the ditch and creek valleys.

Groundwater flow directions in the Berea parallel the Gallia, with flow primarily to the east and north towards Little Beaver Creek and, to a lesser extent, toward portions of the North Drainage Ditch. Because the Berea underlies the Sunbury Shale, groundwater flow in the Berea is unaffected by the bedrock high of the Cuyahoga Shale near X-633 (Plate IX in Appendix A). As a result, the major east-west flow divide that is present in the Gallia is not present in the Berea.

Vertical gradients in most areas indicate that flow is downward from the Gallia to the Berea. These vertical gradients result because of the low hydraulic conductivity of the Sunbury Shale, which separates the Gallia and Berea. Vertical gradients are steepest near the bedrock high in the eastern portion of Quadrant IV (0.64 to 0.76) and in the northwestern portion of Quadrant IV around the X-734 landfill area (0.41 to 0.90). Where the Sunbury is present, all well pairs exhibit a downward gradient from the Gallia to the Berea. The thinning of the Sunbury along the western portion of Quadrant IV generally results in lower gradients. Upward gradients in the Berea are observed where the Sunbury Shale is absent, along the east-west flow divide in the southern portion of Quadrant IV near the Quadrant III/IV boundary (F-11G/F-12B= -0.04, F-07G/F-08B= -0.0004, and X330-PZ05G/X330-PZ04B= +0.11).

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3.0 CHARACTERIZATION OF WASTES

3.1 Introduction

All known waste and process substances disposed of or used at the PORTS facility in Quadrant II have been identified on the Unit Data Sheets in Section 6.0 of the Quadrant II DOCC (Geraghty & Miller, Inc., 1992). A list of these potential constituents of concern is included in Table 3.1. A "Waste Characterization Data Sheet" has been prepared for each waste constituent (Appendix B). The Waste Characterization Data Sheets include the hazard classification, description of physical and chemical properties, and nature of migration and dispersal properties of each constituent. Most of the wastes in Quadrant II occur as mixtures; their physical and chemical properties (particularly migration and dispersal properties) may be different from those of the individual constituents. Therefore, bench-scale studies involving chemical and biological tests may be conducted during the CMS, if required. The approach to the compilation of the data sheets is discussed below.

3.2 Waste Characterization Data Sheets

The primary task in the characterization of wastes was to describe their properties by reviewing published literature. The primary sources of information were Material Safety Data Sheets (Genium Publishing Company, 1989); the *Merck Index* (Budavari, ed., 1989); the *Handbook of Environmental Fate and Exposure Data for Organic Chemicals* (Howard, 1989); *the Handbook of Environmental Fate and Exposure Data for Inorganic Chemicals* (Howard, 1990); *Groundwater Chemicals Desk Reference* (Montgomery, 1991); *Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites* (Clement Associates, 1985); *Water-Related Environmental Fate of 129 Priority Pollutants* (U.S. EPA, 1979); and the *Treatability Database* (U. S. EPA,

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1991). These and other references provide physical and chemical properties, National Fire Protection Association hazardous classifications, and health effects (Immediate Danger to Life and Health [IDLH] Values), as well as other pertinent information. Additional references are included on the individual Waste Characterization Data Sheets (Appendix B).

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4.3.3 X-633-1 Recirculating Water Pump House; X-633-2A Cooling Tower; X-633-2B Cooling Tower; X-633-2C Cooling Tower; X-633-2D Cooling Tower

4.3.3.1 Unit Description

In Quadrant II, the RCW system includes a recirculating water pump house (X-633-1) and four cooling towers (X-633-2A, X-633-2B, X-633-2C, and X-633-2D) with associated basins. Two of the cooling towers (X-633-2A and X-633-2B) have uncovered basin extensions. The approximate dimensions of all the basins are listed below.

Unit	Description	Basin Dimension (ft)	Basin Depth (ft)
X-633-2A	Cooling Tower	363 x 75	15
X-633-2A	Uncovered Basin Extension	325 x 75	15
X-633-2B	Cooling Tower	363 x 75	15
X-633-2B	Uncovered Basin Extension	325 x 75	15
X-633-2C	Cooling Tower	300 x 50	15
X-633-2D	Cooling Tower	363 x 50	15

A network of piping transports RCW between the process buildings and the cooling towers. The RCW system removes the heat of compression from the process gas along with waste heat from a few auxiliary processes. The heat exchange from the compression of uranium hexafluoride involves a double-loop (primary and secondary non-contact) system to minimize the exposure of cooling water to the process gas. The primary heat exchange medium, Freon-114, vaporizes as it absorbs heat. Coolant vapor is collected with a manifold, liquified at a non-contact, water-cooled condenser, and returned to the evaporators. The condenser cooling water is routed to the cooling towers. Heated water entering the cooling tower is exposed to cool atmospheric air. Heat is removed from the water by the air that exits the top of the tower under a forced draft. The cooled water collects in a basin below the tower.

Several chemical species are present in the RCW. These species are added as corrosion inhibitors, fungicides, microbicides, and pH adjusters. In March 1989, a phosphate-based corrosion inhibitor was introduced in place of the chromium-based Orocol in the X-326/X-626 cooling system. The conversion was completed in March 1990. Over the following 2 years, the X-633 cooling system was converted to the phosphate-based inhibitor. The components of the corrosion inhibitor Orocol (Betz Laboratory) and other RCW additives are given in the following tables.

OROCOL COMPONENTS		
Component	Weight %	Function
Sodium Dichromate	78	Anodic inhibitor
Sodium Hexametaphosphate	6	Scale and cathodic inhibitor
Zinc Sulfate	14	Cathodic inhibitor
Sodium Acid Sulfate	2	pH adjustment

OTHER RCW COMPONENTS	
Component	Function
Sulfuric Acid	pH adjustment
Chlorine	Microbiological control

Two fungicides, sodium pentachlorophenate (used before 1982) and cupric arsenate (used after 1982), are wood treatments used on the cooling towers and are not directly added to the RCW. Analyses of water samples have indicated that some wood treatment leaches into the RCW.

One other component of the RCW is treated process effluent from the X-700 Chemical Cleaning Facility. Following deactivation of the X-701C Neutralization Pit in 1988, process effluent that was previously discharged to X-701C was rerouted for treatment in a carbon-filtration system within the X-700 facility. The treated effluent was transported by tanker truck until 1992 to the X-633 Cooling Towers and discharged into one of the RCW basins if it was not reused in the cleaning operation. A temporary unit (X-622T) was set up at the X-700 building to receive tankers with effluent from both the X-700 and X-705 basement sumps. The use of tanker trucks was discontinued after a pipe was connected linking the X-622T with X-700 and X-705.

The following storage tanks are associated with the X-633 facility:

- One outside aboveground storage tank (10,000-gallon capacity) containing sulfuric acid.
- One outside storage tank (500-gallon capacity) containing sulfuric acid.
- One inside storage tank (2,000-gallon capacity) previously contained Orocol.
- One inside (710-gallon capacity) previously contained Orocol.
- Four cylinders (2,000 pounds [lbs] each) of chlorine located inside the facility.

A spill of RCW occurred on March 15, 1980, when a hose became disconnected and fell onto the gravel around the X-633-2D Cooling Tower basin. The outlet of the french drain under the tower was sealed to help contain the release. The volume of loss was undetermined.

Sulfuric acid has been reported to have leaked from a storage tank along the southeast wall of X-633-1 and has accumulated in the fill around the structure. The acid would have mobilized any metal present in the soils; as the acid moved through soil and was neutralized, the metals would have precipitated. A previous cooling tower backfill study found corrosive conditions at a depth of 9 feet below ground surface adjacent to the X-633-1 pump house. A wet black residue that altered the color of the auger bit was noted.

The basins associated with the cooling towers are known to be cracked. An attempt was made to plug several of these cracks, but the effectiveness of the crack sealing is suspect.

Freon-114, a coolant, and to a lesser extent Freon-113, a solvent, have been entering RCW from the process buildings at a minimum rate of 60,000 pounds per year. Typical concentrations of 50 to 60 ppb of Freon-114 in RCW entering the main headers of the cooling towers plant-wide have been detected.

Heated water entering a cooling tower is exposed to cool atmospheric air. Heat is removed from the water by the air that exits the top of the tower under a forced draft. The cooled water collects in a basin below the towers. Drift, consisting of small water droplets, is released with the heated air from the top of the towers. The amount of drift is dependent upon weather conditions.

The loss of RCW through drift to the surrounding soils has been investigated at the X-633 towers. The investigation showed a decrease in chromium and zinc contamination with increased distance from the towers. The production of drift is highly variable and could vary seasonally.

Asbestos fibers have been observed in samples of RCW at X-633. The asbestos was derived from insulating material that previously lined the lower interior of the cooling tower. The asbestos is currently being removed.

4.3.3.2 Potential Contaminants

Potential contaminants directly associated with this unit include sulfuric acid, Orocol, asbestos, Freon-113, and Freon-114. All of these constituents are components of RCW, which is processed at this unit.

4.3.3.3 Potential Releases

The primary pathways for releases at this unit are through airborne emissions from cooling towers, RCW releases from the bottom and/or sides of the cooling tower basins, and leakage from the bottoms of associated RCW lines to adjacent soils. Airborne emissions are being investigated during the site-wide Air RFI. Releases to soils could migrate downward (if contaminants are mobile) to contaminate groundwater.

4.3.3.4 Summary of Investigation: Phase I

UNIT INVESTIGATION SAMPLING POINTS					
Unit	Well(s)	Soil Boring	Hand Auger	Sediment	Surface Water
X-633 RCW Pumphouse/ Cooling Tower	F-05G F-06B X633-01G X633-02G X633-03G X633-04G X633-05G X633-06B X633-07G X633-08G X633-09B X633-10G	RCW-SB201 RCW-SB202 SASW-SB201 X633-SB01 through X633-SB10	--	--	X633-SW01

UNIT INVESTIGATION SAMPLING POINTS					
Unit	Well(s)	Soil Boring	Hand Auger	Sediment	Surface Water
X-633 Drift Area	--	--	X633-HA01 through X633-HA10	--	--

To determine if releases to soils from cooling-tower drift had occurred, a drift study was conducted in the wooded area on the hills northeast of the X-633 Cooling Towers (Plate I in Appendix A). This area was selected because the prevailing wind direction of the site is to the northeast. A random sampling method was used in the drift study to select soil locations. A node-centered systematic sampling grid with a spacing of 50 feet was superimposed on a map of the hillside. Each node in the grid was assigned a number; a random number generator was used to select ten random numbers in the range included on the hillside. The nodes corresponding to these random numbers were used as sampling locations. Ten soil samples were collected to a depth of 6 inches at selected locations using a hand-auger soil sampler. Five soil samples (X633-HA02, X633-HA03, X633-HA04, X633-HA06, and X633-HA09) were submitted for Level III analyses of TAL, fluoride, and radiological parameters. Four soil samples (X633-HA01, X633-HA07, X633-HA08, and X633-HA10) were submitted for Level III analyses of chromium and zinc. One soil sample (X633-HA05) was submitted for Level III analyses of chromium, zinc, and radiological parameters. All of these samples were also analyzed onsite with a field GC (Level II) for trichloroethene.

Ten soil borings were drilled around the cooling tower basins at the unit to determine if releases to soils had occurred. X633-SB01, X633-SB02, and X633-SB03 were drilled on the east side of the X633-2A Cooling Tower, X633-SB04, X633-SB05,, and X633-SB06 were drilled on the north side of the X633-2B Cooling Tower (Plate

I in Appendix A). X633-SB07 was drilled on the south side of the X633-2B Cooling Tower and X633-SB08, X633-SB09, and X633-SB10 were drilled on the northeast, southeast and northwest sides of the X633-2B Cooling Tower, respectively. Additionally, RCW-SB201, RCW-SB202, and SASW-SB201 were installed in the vicinity of this unit to investigate adjacent units. Continuous soil samples were collected from the ground surface to bedrock using stand and hollow-stem augering and split-spoon sampling techniques. All of these soil samples were analyzed onsite with a field GC for trichloroethene (Level II). Continuous soil samples were also collected from the ground surface to a depth of 16 feet for Level III analyses of pH and total chromium at X633-SB01 through X633-SB10, RCW-SB201, and RCW-SB202. One soil sample from each borehole was collected at a random depth for Level III analyses of TCL/TAL, Freon-113, fluoride and radiological parameters. An additional soil sample was collected at X633-SB07 at 18 feet for Level III analyses of TCL/TAL, Freon-113, fluoride, and radiological parameters.

Eight Gallia and two Berea wells were installed around the perimeter of the X-633 cooling towers to better define groundwater flow and to determine if releases to groundwater from the unit have occurred. During drilling of Gallia well borings, continuous soil samples were collected from ground surface to bedrock using standard hollow-stem augering and split-spoon sampling techniques. All of these soil samples were analyzed onsite with a field GC (Level II) for trichloroethene. Continuous soil samples were also collected from the ground surface to a depth of 16 feet for Level III analyses of pH and total chromium. One random soil sample from each borehole was collected at a random depth for Level III analyses of TCL/TAL, Freon-113, fluoride, and radiological parameters. Groundwater samples were collected from all the newly-installed wells and from two existing wells (F-05G and F-06B) for onsite analyses with a field GC (Level II) for trichloroethene. X633-01G through X633-05G, X633-07G, X633-09B, X633-10G, F-05G, and F-06B were also sampled for Level III analysis of metals and filtered metals. X633-06B was sampled for Level III analyses of

Appendix IX and radiological parameters. X633-08G was sampled for Level III analyses of Appendix IX, filtered metals and radiological parameters. To further characterize RCW from X-633, a surface-water sample was collected from the X633-2B Cooling Tower basin for Level III analyses of Appendix IX and radiological parameters and onsite Level II analysis of trichloroethene with a field GC.

All sample locations associated with Quadrant II are shown on Plate I (Appendix A).

4.3.3.5 Analytical Results: Phase I

4.3.3.5.1 Results of Basin-Water Analyses: Phase I

A list of analytes detected in basin-water samples collected at X-633 is presented in Appendix D1; a matrix of detected organic compounds and radiological parameters is presented in Table 4.11a. A table of detected zinc and chromium values is presented in Table 4.11b. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for basin-water samples are presented on Figures 4.6a through 4.6d. VOCs were detected in two of two samples collected from one location. Bromodichloromethane was detected at X633-SW01 at a concentration of 2.1J μg/l. Chloroform was detected at X633-SW01 and X633-SW01D (duplicate) at concentrations of 6.8 μg/l and 5.6 μg/l, respectively. No other VOCs and no SVOCs, PCBs or pesticides were detected in basin-water samples collected at this unit.

Chromium was detected at X633-SW01 and X633-SW01D (duplicate) at concentrations of 940 μg/l and 890 μg/l, respectively. Dissolved chromium was detected at X633-SW01 and X633-SW01D (duplicate) at concentrations of 830 μg/l and 850 μg/l, respectively. Zinc was detected at X633-SW01 and X633-SW01D (duplicate) at concentrations of 130J μg/l and 170J μg/l, respectively. Dissolved zinc was detected at X633-SW01 and X633-SW01D (duplicate) at concentrations of 120 μg/l.

Radiological parameters were detected in two of two samples collected from one location. Gross beta was detected at X633-SW01 and X633-SW01D (duplicate) at activities of 72 pCi/l and 57 pCi/l, respectively. No other radiological parameters were detected in basin-water samples collected at this unit.

Level II field-GC analysis results for trichloroethene are presented in Appendix E. No trichloroethene was detected in basin-water samples collected from the basin of this unit.

4.3.3.5.2 Results of Soil Analyses - X-633 Drift Area: Phase I

A list of analytes detected in soil samples collected at the X-633 Drift Area is presented in Appendix D1; a matrix of detected radiological parameters is presented in Table 4.11c. A table of detected chromium and zinc values is presented in Table 4.11d. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for soil samples are presented on Figure 4.6e.

Chromium was detected in ten soil samples at concentrations ranging from 5.3 mg/kg (X633-HA01) to 15 mg/kg (X633-HA03). Zinc was detected in ten soil samples at concentrations ranging from 20J mg/kg (X633-HA01) to 80J mg/kg (X633-HA04).

Radiological parameters were detected in seven of seven samples collected from six locations. Total uranium was detected in seven soil samples at concentrations ranging from 2.4 mg/kg (X633-HA03) to 3.5 mg/kg (X633-HA02). Gross alpha was detected in four samples at activities ranging from 6 pCi/g (X633-HA09) to 10 pCi/g

(X633-HA04 and X633-HA05). Technetium was detected in four samples at activities ranging from 0.2 pCi/g (X633-HA02, X633-HA04, and X633-HA09) to 0.3 pCi/g (X633-HA03). No other radiological parameters were detected in soil samples collected at this unit.

Level II field-GC analysis results for trichloroethene are presented in Appendix E. No trichloroethene was detected in soil samples collected at this unit.

4.3.3.5.3 Results of Soil Analyses: Phase I

A list of analytes detected in soil samples collected at X-633 is presented in Appendix D1; a matrix of detected organic compounds and radiological parameters is presented in Table 4.11e. A table of detected chromium and zinc values is presented in Table 4.11f. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for soil samples are presented on Figures 4.6f through 4.6h. VOCs were detected in 2 of 24 samples collected from 21 locations. Xylenes were detected at X633-07G-10 ft at a concentration of 0.33J μg/kg. Acetone was detected at X633-03G-08 ft at a concentration of 160J μg/kg. No other VOCs were detected in soil samples collected at this unit.

PAHs were detected in 3 of 24 samples collected from 21 locations. PAHs were detected in three soil samples at concentrations ranging from 42J μg/kg [benzo(k)fluoranthene at SASW-SB201-02 ft] to 360J μg/kg (fluoranthene at X633-04G-04 ft). SVOCs were detected in 8 of 24 samples collected from 21 locations. 2-Chlorophenol was detected at RCW-SB201-06 ft at a concentration of 10J μg/kg. Benzoic acid was detected in six soil samples at concentrations ranging from 50J μg/kg (RCW-SB202-10 ft) to 140J μg/kg (X633-01G-12 ft and X633-SB07-02 ft). Bis(2-ethylhexyl)phthalate was detected at X633-10G-12 ft at a concentration of 490J μg/kg. Diethylphthalate was detected at X633-04G-04 ft at a concentration of 990 μg/kg. No other SVOCs, PCBs or pesticides were detected in soil samples collected in the vicinity of this unit.

Chromium was detected in 175 soil samples at concentrations ranging from 1.9 mg/kg (RCW-SB201-16 ft) to 600 mg/kg (X633-04G-02 ft). Zinc was detected in 21 soil samples at concentrations ranging from 26 mg/kg (X633-SB01-14 ft) to 100 mg/kg (X633-SB07-02 ft).

Radiological parameters were detected in 24 of 24 samples collected from 21 locations. Total uranium was detected in 24 soil samples at concentrations ranging from 2.4 mg/kg (X633-SB10-08 ft) to 4.0 mg/kg (RCW-SB202-10 ft). Gross alpha was detected in nine soil samples at activities ranging from 5 pCi/g (X633-01G-12 ft and X633-10G-12 ft) to 9 pCi/g (X633-SB04-08 ft). Gross beta was detected at RCW-SB202-10 ft and X633-SB02-02 ft at activities of 13 pCi/g and 9 pCi/g, respectively. No other radiological parameters were detected in soil samples collected in the vicinity of this unit.

Level II field-GC analysis results for trichloroethene are presented in Appendix E. Trichloroethene was detected at RCW-SB201-20 ft and X633-SB01-24 ft at concentrations of 110 ppb and 10 ppb, respectively.

4.3.3.5.4 Results of Groundwater Analyses: Phase I

A list of analytes detected in groundwater samples collected at X-633 is presented in Appendix D1; a matrix of detected organic compounds and radiological parameters is presented in Table 4.11g. A table of detected chromium and zinc values is presented in Table 4.11h. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for groundwater samples are presented on Figures 4.6i through 4.6k. VOCs were detected in one of two samples collected from two locations. Acetone, trichloroethene, and xylenes were detected at X633-06B at concentrations of 180 μg/l, 2.7J μg/l, and 1.2J μg/l, respectively. No other VOCs were detected in the groundwater samples collected in the vicinity of this unit.

PAHs were detected in one of two samples collected from two locations. 2-Methylnaphthalene and naphthalene were detected at X633-06B at concentrations of 1.2J μg/l and 0.48J μg/l, respectively. No other SVOCs and no PCBs or pesticides were detected in groundwater samples collected at this unit.

Chromium was detected in 17 groundwater samples at concentrations ranging from 16 μg/l (X633-08G and X633-02G) to 780 μg/l (X633-04G). Dissolved chromium was detected in four groundwater samples at concentrations ranging from 20 μg/l (X633-04G) to 250J μg/l (X633-02GD). Zinc was detected in 17 groundwater samples at concentrations ranging from 86 μg/l (X626-02G) to 37,000 μg/l (X633-10G). Dissolved zinc was detected in four groundwater samples at concentrations ranging from 24 μg/l (X633-08G) to 130 μg/l (X633-10G).

Radiological parameters were detected in two of two samples collected from two locations. Gross alpha was detected at X633-06B at an activity of 80 pCi/l. Gross beta was detected at X633-06B and X633-08G at activities of 92 pCi/l and 40 pCi/l, respectively. No other radiological parameters were detected in the groundwater samples collected in the vicinity of this unit.

Level II field-GC analysis results for trichloroethene are presented in Appendix E. Trichloroethene was detected in eight groundwater samples at concentrations ranging from 6 ppb (X633-06B) to 68 ppb (X633-04G).

4.3.3.6 Summary of Investigation: Phase II

UNIT INVESTIGATION SAMPLING POINTS					
Unit	Well(s)	Soil Boring	Hand Auger	Sediment	Surface Water
X-633 RCW Pumphouse/ Cooling Tower	F-05G F-06B X633-01G through X633-05G X633-06B X633-07G X633-08G X633-09B X633-10G X633-PZ01G through X633-PZ04G X701-36G X701-44G	--	--	--	X633-SW02

To provide updated information on RCW constituents and additional data in support of the CMS, one surface-water sample was collected from the X-633 Cooling Tower basin for Level III analyses of metals. Level II turbidity analyses and Level III analyses of total mobile metals (filtered through a 5.0-μm filter) and unfiltered metals were also conducted on the surface-water sample. The sample was also analyzed onsite with a field GC for the presence of trichloroethene (Level II).

To determine the extent of possible metals contamination in groundwater and to provide additional data in support of the CMS, 21 groundwater samples were collected from the wells and piezometers shown in the above table. Groundwater samples were collected from Wells X633-01G, X633-02G, X633-03G, X633-04G, X633-05G, X633-06B, X633-07G, X633-08G, X633-09B, X633-10G, X701-36G, X701-44G, F-05G, and F-06B for Level III analyses of VOCs, metals, hexavalent chromium, and radiological parameters. Groundwater samples were also collected from Piezometers X633-PZ01G through X633-PZ04G for Level III analyses of metals. Level II turbidity analyses and Level III analyses of total mobile metals (filtered through a 5.0-μm filter) and unfiltered metals were conducted on all groundwater samples. All samples were analyzed onsite with a field GC for trichloroethene (Level II).

All sample locations associated with Quadrant II are shown on Plate I (Appendix A).

4.3.3.7 Analytical Results: Phase II

4.3.3.7.1 Results of Basin-Water Analyses: Phase II

A list of analytes detected in basin-water samples collected at X-633 is presented in Appendix D1. A table of detected chromium and zinc values is presented in Table 4.11j. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for basin-water samples are presented on Figures 4.6a through 4.6d. Chromium was detected at X633-SW02 at a concentration of 14 μg/l. Zinc and total mobile zinc were detected at X633-SW02 at concentrations of 31 μg/l and 26 μg/l, respectively.

4.3.3.7.2 Results of Groundwater Analyses: Phase II

A list of analytes detected in groundwater samples collected at X-633 is presented in Appendix D1; a matrix of detected organic compounds and radiological parameters is presented in Table 4.11k. A table of detected chromium and zinc values is presented in Table 4.11l. Sampling locations are shown on Plate I (Appendix A). Maps showing sample locations and associated analytical results for groundwater samples are presented in Figures 4.6i through 4.6k. VOCs were detected in 5 of 16 samples collected from 14 locations. 1,1,1-Trichloroethane was detected at X633-07G at a concentration of 1.2J μg/l. Chlorobenzene was detected at X633-03GD (duplicate) at a concentration of 1.1J μg/l. Chloroform was detected at X633-07G at a concentration of 1.1J μg/l. Trichloroethene was detected at F-05G and X633-03G at concentrations of 1.1J μg/l and 6.6J μg/l, respectively. Trichlorofluoromethane was detected at X701-36G at a concentration of 3.6J μg/l. No other VOCs were detected in groundwater samples collected at this unit.

Total chromium was detected in 17 groundwater samples at concentrations ranging from 16 μg/l (X633-02G and X633-08G) to 780 μg/l (X633-04G). Zinc was detected in 17 groundwater samples at concentrations ranging from 86 μg/l (X633-02G) to 37,000 μg/l (X633-10G). Dissolved chromium was detected in four groundwater samples at concentrations ranging from 20 μg/l (X633-04G) to 250J μg/l (X633-02GD [duplicate]). Dissolved zinc was detected in four groundwater samples at concentrations ranging from 24 μg/l (X633-08G) to 130 μg/l (X633-10G).

Radiological parameters were detected in 6 of 16 samples collected from 14 locations. Gross alpha was detected in six groundwater samples collected at this unit at activities ranging from 46 pCi/l (X633-07G) to 274 pCi/l (X633-04G). Gross beta was detected in six groundwater samples collected at this unit at activities ranging from 55 pCi/l (X633-01G) to 301 pCi/l (X633-02G). No other radiological parameters were detected in groundwater samples collected at this unit.

Level II field-GC analysis results for trichloroethene are presented in Appendix E. No trichloroethene was detected in groundwater samples collected at this unit.

4.3.3.8 Discussion

During Phase I, basin water from the X-633 Cooling Tower Basin was collected and analyzed for Appendix IX and radiological parameters to quantitatively evaluate the RCW constituents. The VOCs bromodichloromethane and chloroform were detected below PQLs in this sample. Total and dissolved chromium and zinc were also detected. Basin water from the X-633 Cooling Tower basin was resampled during the Phase II Investigation for Level III analyses of metals to assess constituents present in the currently used phosphate-based RCW. Chromium and zinc were detected at significantly lower concentrations in these samples.

During Phase I, to assess possible contamination resulting from drift originating at the X-633 Cooling Towers, ten surface-soil samples were collected in the prevailing downwind direction (northeast) of the cooling towers. Technetium was detected at its PQL in four surface-soil samples. Based upon these results, a possible release of technetium to surface soil in the X-633 drift area has occurred. Statistical analysis of results for metals in soils indicate that a sufficient number of samples has been collected for the drift study to fully characterize metal concentrations. At all locations, total chromium and zinc were consistently detected at 5.3 to 15 mg/kg and 20 to 80 mg/kg, respectively. Although metals concentrations have not been assessed relative to the BSI, concentrations of these metals do not appear elevated relative to metal concentrations in other samples at the PORTS facility.

During Phase I, acetone was detected slightly above its PQL at X633-03G-08 ft. Because it was detected only slightly above its PQL and in only one soil sample, the acetone is likely a laboratory contaminant and not a release from this unit. Xylenes were detected below PQLs in one soil sample. SVOCs (including PAHs) were detected below PQLs in soils at eight locations near this unit and above PQLs at two locations. PAH concentrations detected at this unit are consistent with or lower than PAH levels detected in soils throughout the site. These levels are consistent with anthropogenic levels associated with plant operations and infrastructure. Based upon the Phase I results, a release of SVOCs and a possible release of VOCs to soils has occurred at this unit.

During Phase I, to determine if releases of RCW to soils had occurred, continuous soil samples were collected from ground surface to the water table for analysis of total chromium and soil pH. Releases from RCW lines or basins would be indicated by increased metal concentrations and decreased pH levels. Soil pH levels do appear decreased near the base of RCW lines at X633-01G, X633-02G, X633-03G, and X633-SB04 through X633-SB09, indicating that a possible release of RCW to soils has occurred. Although metals concentrations have not been assessed relative to the BSI, total chromium and zinc do not appear elevated relative to other samples at the PORTS facility with the exception of X633-02G-04 ft (150 mg/kg total chromium) and X633-04G-02 ft (600 mg/kg total chromium), which indicate that a possible release of RCW to surface and near soils may have occurred.

Because the nature and extent of contamination (VOCs and SVOCs) in soil have been determined, the data set is considered complete; no further RFI work is recommended.

During Phase I, groundwater was collected from nine Gallia wells and three Berea wells in the vicinity of X-633. No VOCs, SVOCs, PCBs, pesticides, or technetium were detected in Gallia groundwater at this unit. The VOC acetone was detected above its PQL, and trichloroethene and xylenes were detected below PQLs at X633-06B. Since acetone was detected above its PQL in only one groundwater sample, it is likely a laboratory contaminant and not a release from this unit. The PAHs 2-methylnaphthalene and naphthalene were also detected below PQLs at X633-

06B. Based on these results, a possible release of VOCs and SVOCs (PAHs) to the Berea may have occurred.

Although background levels for metals in Gallia groundwater have not been assessed relative to the BSI, dissolved and total chromium and zinc concentrations are elevated at X633-01G, X633-02G, X633-04G, X633-07G, and X633-10G. Because X-633 is on a groundwater and bedrock high, groundwater flow in the Gallia in the X-633 area is radially outward from the unit in all directions. Based upon these results, a release of metals to Gallia groundwater has occurred. Although background levels in Berea groundwater have not been assessed relative to the BSI, metal concentrations in Berea groundwater do not appear elevated relative to other samples at the PORTS facility.

Gross alpha and gross beta were detected in groundwater from five Gallia and one Berea well at X-633. Neither total uranium nor technetium (the primary alpha and beta emitters, respectively) was detected in these or any other groundwater samples in the vicinity of X-633. Levels of radiological parameters in surface-soil and subsurface-soil samples at this unit do not indicate the presence of a source. In addition, many of the Gallia wells at this unit are partially or entirely screened in a thick zone of weathered Sunbury Shale, a natural source of radium and radon (alpha and beta emitters). Results of the site-wide Groundwater Radiological Investigation presented in Volume VI of the Quadrant IV RFI (Geraghty & Miller, Inc., 1994b) suggest that the elevated levels of gross alpha and gross beta are due to the presence of natural radium and radon. This conclusion will be evaluated as part of the CAS/CMS after the referenced report is finalized.

During Phase II, to further evaluate the extent of VOC and metal contamination in the vicinity of X-633, 14 wells and 4 piezometers were sampled. VOCs were detected in groundwater slightly above or below PQLs at three Gallia locations. Based upon these results, a release of VOCs to Gallia groundwater has occurred. Because these wells are within and adjacent to the unit, they likely represent the maximum concentrations present. Relatively high concentrations of total mobile chromium and zinc were found in Gallia groundwater confirming the Phase I results. Hexavalent chromium was not detected in any groundwater samples. Although a release of metals to groundwater has occurred at this unit, plume boundaries cannot be fully defined until background levels of these constituents are assessed relative to the BSI.

Because the nature and extent of contamination (VOCs) in groundwater have been determined, the data set is considered complete; no further RFI work is recommended.

The inorganic constituents and radiological parameters for this unit will be evaluated using the results presented in the BSI and will be addressed in the CAS/CMS.

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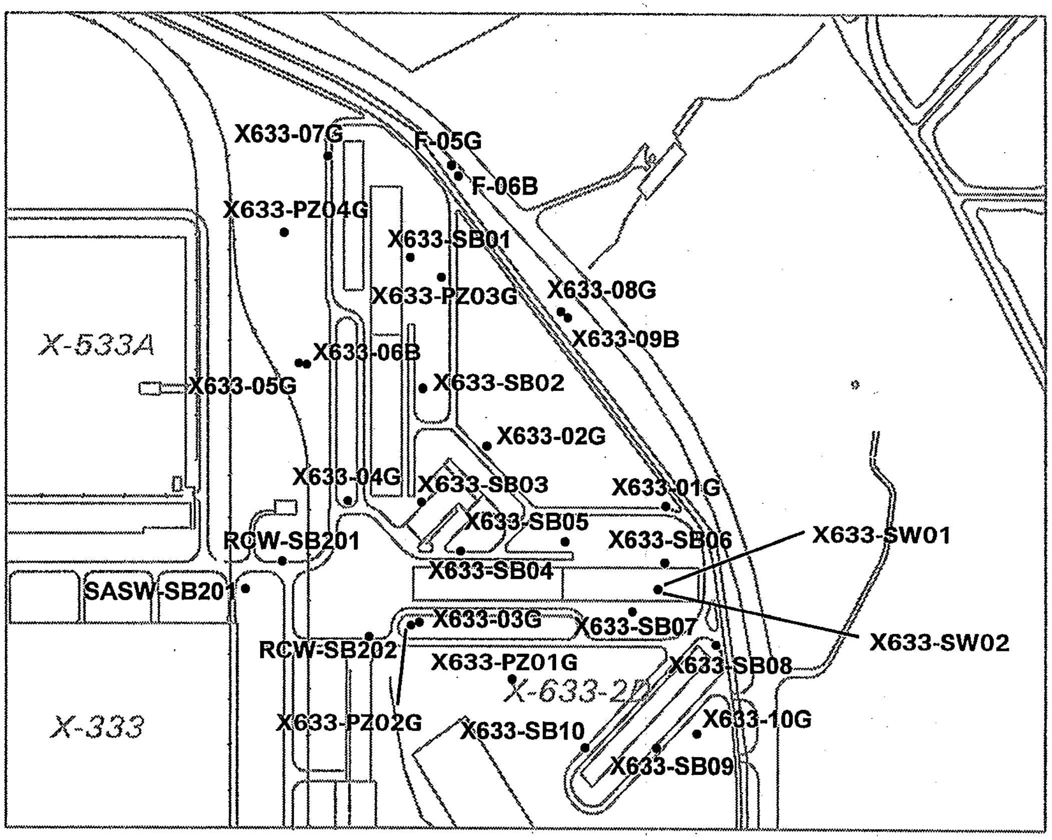
Figure 4.6a Sample Locations, X-633 Pumphouse/Cooling Tower Basin and RCW System, Quadrant II RFI



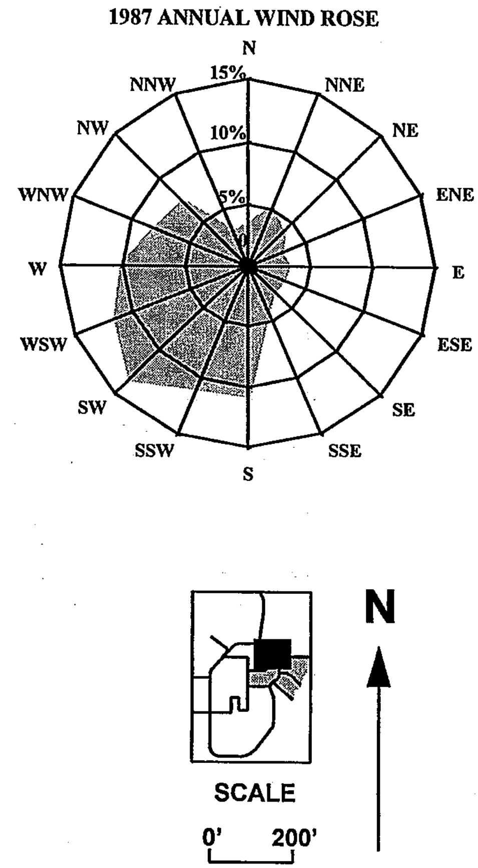


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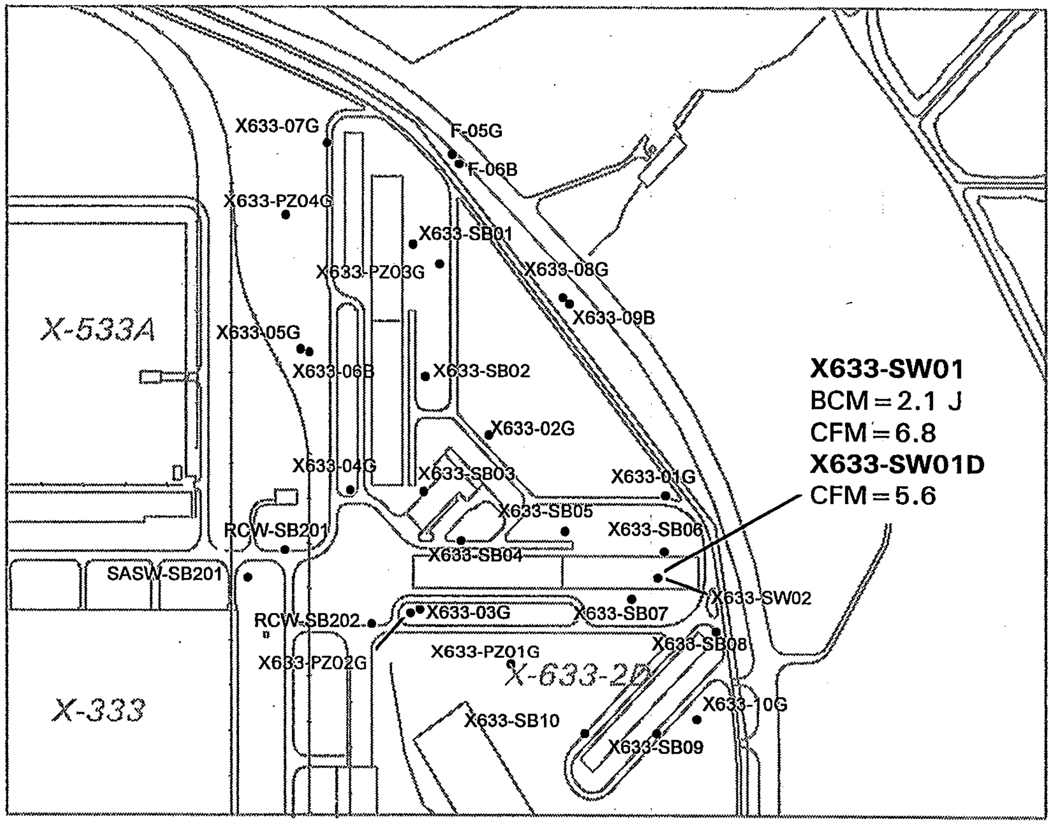
Figure 4.6b Concentration of VOCs in Basin-Water Samples at X-633 Pumphouse/Cooling Tower Basin and RCW System, Quadrant II RFI



VOCs (ug/l)

BCM=Bromodichloromethane
CFM=Chloroform

J=ESTIMATED VALUE
ND=NO VOCs DETECTED

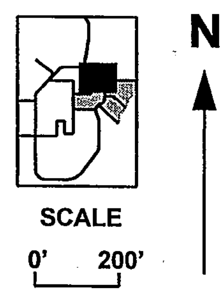


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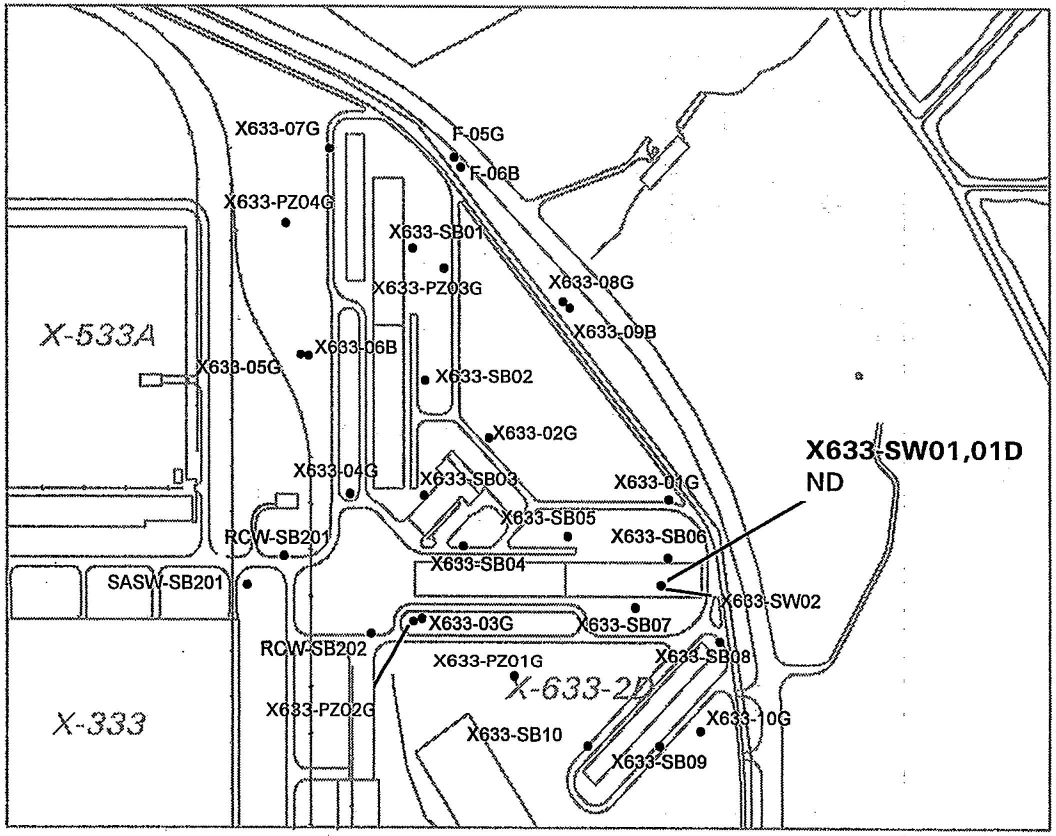
Figure 4.6c Concentration of SVOCs, PCBs and Pesticides in Basin-Water Samples at X-633 Pumphouse/Cooling Tower Basin and RCW System, Quadrant II RFI



INDICATOR SVOCs and PCBs / PESTICIDES (ug/l)

A = ACENAPHTHENE
C = CHRYSENE
F = FLUORANTHENE
P = PYRENE
PCB54 = AROCLOR-1254
PCB60 = AROCLOR-1260

J = ESTIMATED VALUE
ND = NO SVOCs / PCBs DETECTED
* = SVOCs OTHER THAN INDICATORS PRESENT

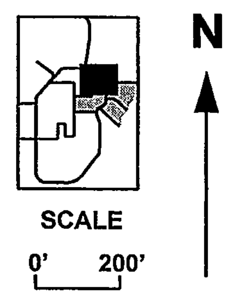


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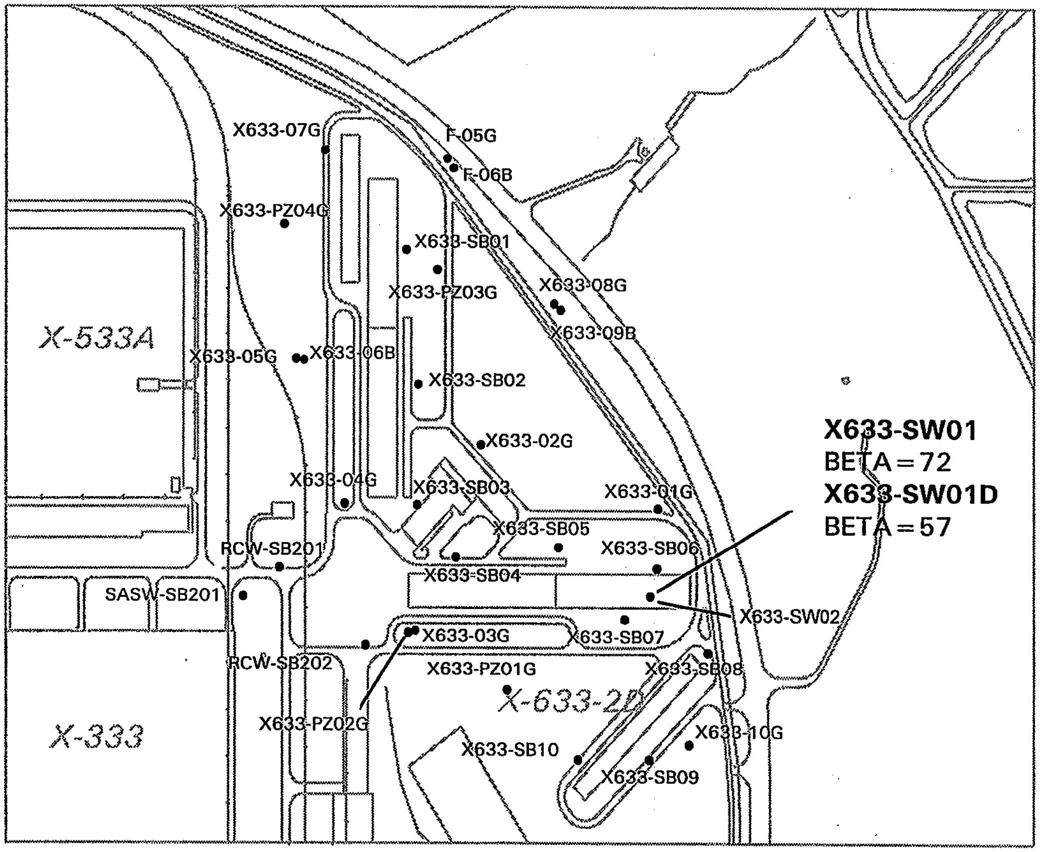
Figure 4.6d Concentration of Radiological Parameters in Basin-Water Samples at X-633 Pumphouse/Cooling Tower Basin and RCW System, Quadrant II RFI



RADIOLOGICAL PARAMETERS

U = TOTAL URANIUM (mg/l)
ALPHA = GROSS ALPHA (pCi/l)
Tc = TECHNETIUM (pCi/l)
BETA = GROSS BETA (pCi/l)

J = ESTIMATED VALUE
ND = NO RADIOLOGICAL PARAMETERS DETECTED